United States. Engineers

50TH CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, pt. 2, vol. II.

ANNUAL REPORT

OF THE

CHIEF OF US ENGINEERS,

UNITED STATES ARMY,

TO THE

SECRETARY OF WAR,

FOR

THE YEAR 1887.

IN FOUR PARTS.

PART IV.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

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C. B. COMSTOCK, Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.,
CHARLES R. SUTER, Major of Engineers, U. S. A.,
Mr. HENRY MITCHELL, Coast and Geodetic Survey,
Mr. B. M. HARROD, Civil Engineer,
Mr. S. W. FERGUSON, Civil Engineer,
Mr. ROBERT S. TAYLOR,
Commissioners.

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ALEX. MACKENZIE, Major of Engineers, U. S. A.,
O. H. ERNST, Major of Engineers, U. S. A.,
Mr. G. C. BROADHEAD,
Mr. WILLIAM J. BROATCH,
Commissioners.

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MAINTENANCE AND REPAIRS OF WASHINGTON AQUEDUCT—INCREASING WATER SUPPLY OF THE CITY OF WASHINGTON—ERECTION OF FISH-WAYS AT THE GREAT FALLS OF THE POTOMAC.

REPORT OF MAJOR G. J. LYDECKER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1887, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Washington Aqueduct.
2. Increasing the water supply of the city of Washington.
3. Erection of fish-ways at the Great Falls of the Potomac.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., August 27, 1887.

SIR: I have the honor to transmit herewith reports of operations on the Washington Aqueduct; increasing the water of Washington, D. C.; and erection of fish-ways at Great Falls of the Potomac, for the fiscal year ending June 30, 1887.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

V V 1.

WASHINGTON AQUEDUCT.

Operations under the appropriations for the Washington Aqueduct have for their object the maintenance and general repairs of the aqueduct, with its accessory structures, and also of the Government supply mains by which the water is brought to the system of distributing mains in Washington and Georgetown. The principal elements of the whole combination are: (1) The aqueduct, 11½ miles long, by which the water is conducted from the Great Falls of the Potomac to the distributing reservoir. (2) The masonry dam, 2,877 feet long at the Great Falls, at which place are also a gate-house, where the flow of water into the aqueduct is regulated, and a keeper's dwelling. (3) The receiving reservoir,

with its influent and effluent gate-houses, sluice-tower, waste-weir, and keeper's dwelling. (4) The distributing reservoir, with its influent and effluent gate-houses, screen-well house, and keeper's dwelling. (5) The high service reservoir in Georgetown. (6) The Government mains by which the water supply is taken from the distributing reservoir to Georgetown and Washington. (7) The bridge over Rock Creek (at the crossing of Pennsylvania avenue), through the arched ribs of which the water supply for Washington passes; adjoining this bridge, on the Georgetown side, are the aqueduct office building, stable, and work-shop.

The history of operations presents but little variety from year to year, as it is ordinarily a record of routine work, and current repairs of a minor character; such was particularly the case during the past year. The Government mains were regularly flushed, and the numerous gates and stops by which the supply is regulated were kept properly oiled and packed, thereby maintaining them in good working order; the usual precautions were observed to prevent ice, drift, fish, etc., from getting into the aqueduct; the grounds about the reservoirs were kept in good, cleanly condition, and every effort made to prevent the introduction of any objectionable substances into the water supply; the fences around Government property at the Falls and the reservoirs, aggregating about 16,500 feet in length, were whitewashed, and about 3,000 feet thereof were renewed or repaired; ruts in the macadam covering of the aqueduct were filled, embankments repaired where washed or cut, and the culverts and ditches along the line of the aqueduct road all cleaned out and kept in good shape. Most of the work above indicated is of a purely routine character, and is done under the immediate supervision of the keepers along the line of the aqueduct, each of whom is charged with the care of certain specified sections, and all of whom receive their instructions in relation thereto from the superintendent of the aqueduct.

In the nature of what may be classed as special or unusual repairs, I have to report: (1) The replacing of the roadway of the bridge over Rock Creek, to which purpose 12,533 feet, B. M., of Georgia heart-pine was applied. (2) The placing of riprap backing against the new dam spanning the Virginia Channel of the Potomac at the Great Falls, to which end a small scow (40 by 14 feet) was constructed and a force put at work in the quarry that had been opened on the Government property on the Virginia shore; the amount of stone quarried, boated to the dam, and leveled off was about 2,016 cubic yards. (3) The conduit road was widened at places where the embankments were dangerously narrow, such as to barely admit the passage of meeting vehicles; the aggregate length of road so widened was about 15,800 feet, the increase of width varying from 10 feet to 20 feet, providing in this way a roadway whose least width is 20 feet. (4) The doors of all gate-houses were sanded down and painted; the iron cornices and beams of the gate-houses were painted, as also were the keepers' houses. (5) About 1,500 linear feet of paved gutter was built along the conduit road where it passes by the distributing reservoir, thereby improving the surface drainage at that place. (6) The poles of the aqueduct telephone line on Thirty-fifth street, Georgetown, were removed to the new curb line of the street in response to a request from the Commissioners of the District. (7) In addition to scattering repairs to the macadam of the conduit road, a layer of stone 6 inches deep and 11 feet wide was spread over a length of about 2,000 feet and thoroughly rolled; and I would note that the maintenance of a good stone roadway over the aqueduct is of the greatest importance as a guard

against injury to the conduit from the deep cuts made by heavy traffic during certain parts of the year, especially in the spring-time. Three old wooden culverts on the line of the road were rebuilt in stone, and one new pipe culvert. At the close of the fiscal year the general condition of everything about the aqueduct was as good as the means available could make it.

The outflow of water from the distributing reservoir, as measured during the 24 hours ending at 6 a. m. June 25, 1887, was 26,878,424 gallons, being 1,335,918 gallons more than the outflow as measured about the same time in the year preceding. (See Table 1.)

The water supply as it passed the effluent gate-house of the distributing reservoir was clear on 256 days, slightly turbid 39, turbid 32, and very turbid 38; the supply in this respect being an improvement on that of the previous year, during which *clear* water passed the effluent on only 147 days. (See Tables 2 and 3.)

The water-level at the inlet to the aqueduct at the Great Falls has varied from a maximum of 3 feet to a minimum of 0.7 feet above the crest of the dam. This, it will be observed, is the first in a long series of years that the water level has not fallen below the crest of the dam, the natural result of its extension and completion to the Virginia shore. (See Table 2.)

The average water pressure for the year in the supply mains at the crossing of Rock Creek, as recorded daily at 9 a. m., was 31.03 pounds per square inch; the maximum 9 a. m. pressure was 35 pounds, and the minimum 28.5 pounds. The average pressure during 1886 was 32.04 pounds. (See Tables 1 and 4.)

The following tables, from which the items above noted were deduced, will furnish more detailed information in relation to the same points:

TABLE 1.—*Showing hourly flow from distributing reservoir for the twenty-four hours ending June 25, 1887.*

Date.	Fall.	Consumption per hour.	Date.	Fall.	Consumption per hour.
June 24—	*Feet.*	*Gallons.*	June 24—	*Feet.*	*Gallons.*
From 6 a. m. to 7 a. m...	.08	1,128,854	From 8 p. m. to 9 p. m....	.09	1,256,927
From 7 a. m. to 8 a. m...	.09	1,260,034	From 9 p. m. to 10 p. m..	.07	976,931
From 8 a. m. to 9 a. m...	.08	1,127,206	From 10 p. m. to 11 p. m..	.07	976,337
From 9 a. m. to 10 a. m..	.09	1,267,179	From 11 p. m. to 12 p. m..	.07	975,743
From 10 a. m. to 11 a. m.	.09	1,266,198	From 12 p. m. to 1 a. m...	.07	975,149
From 11 a. m. to 12 m...	.08	1,124,685	June 25—		
From 12 m. to 1 p. m....	.09	1,264,344	From 1 a. m. to 2 a. m....	.08	1,113,729
From 1 p. m. to 2 p. m...	.09	1,263,362	From 2 a. m. to 3 a. m....	.07	973,877
From 2 p. m. to 3 p. m...	.08	1,122,164	From 3 a. m. to 4 a. m....	.07	973,283
From 3 p. m. to 4 p. m...	.09	1,261,508	From 4 a. m. to 5 a. m....	.07	972,689
From 4 p. m. to 5 p. m...	.08	1,120,516	From 5 a. m. to 6 a. m...	.07	972,095
From 5 p. m. to 6 p. m...	.09	1,259,654			
From 6 p. m. to 7 p. m...	.08	1,118,868	Total..............	1.92	26,878,424
From 7 p. m. to 8 p. m...	.08	1,111,092			

The outflow during twenty-four hours, as measured in the latter part of June, for the past fourteen years is as follows:

Year.	Gallons.	Year.	Gallons.	Year.	Gallons.
1874..............	15,554,848	1879..............	25,947,642	1884..............	24,827,013
1875..............	21,000,000	1880..............	25,740,138	1885..............	25,219,194
1876..............	24,177,797	1881..............	26,525,991	1886..............	25,542,476
1877..............	23,252,932	1882..............	29,727,864	1887..............	26,878,424
1878..............	24,885,945	1883..............	24,314,715		

TABLE 2.—*Showing for each day in the year, (a) condition of water at Great Falls' receiving reservoir, and distributing reservoir; (b) heights of water over dam at Great Falls; (c) 9 a. m. pressures at Rock Creek.*

Day of month.	July, 1886.					August, 1886.					September, 1886.				
	Condition of water.			Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.	Condition of water.			Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.	Condition of water.			Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.
	Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.			Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.			Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.		
1.	30	36	32	1.65	32.0	3	11	14	2.10	32.0	25	36	36	.80	31.0
2.	32	36	36	1.70	32.5	1	15	12	2.30	32.0	36	36	36	.80	30.0
3.	5	17	36	2.15	32.0	2	12	10	2.20	32.0	36	36	36	.80	29.5
4.	9	24	36	2.00	32.5	4	12	12	2.70	31.5	36	34	36	.80	30.0
5.	5	18	36	2.15	32.5	6	15	15	2.10	31.5	36	36	36	.80	31.0
6.	6	20	36	1.97	32.0	8	12	18	2.02	31.5	36	36	36	.80	30.0
7.	9	30	36	1.77	32.0	10	16	18	2.00	31.5	36	36	36	.80	30.5
8.	19	34	36	1.77	32.0	14	12	19	1.92	32.5	36	36	36	.80	30.5
9.	27	36	36	1.70	32.0	14	14	20	1.92	31.0	36	36	36	.80	31.0
10.	20	36	36	1.72	31.5	10	20	21	2.00	31.5	36	36	36	.70	30.5
11.	27	36	36	1.70	32.5	15	27	26	2.02	31.0	36	36	36	.70	31.0
12.	30	36	36	1.70	31.0	20	32	30	2.00	31.0	36	36	36	.70	30.5
13.	33	36	36	1.70	32.0	28	36	36	2.70	31.0	36	36	36	.70	30.5
14.	6	36	36	1.77	31.5	28	36	36	2.45	31.0	36	36	36	.70	30.5
15.	6	36	36	1.72	32.0	30	36	36	1.70	31.0	36	36	36	.70	31.0
16.	3	36	36	1.80	32.0	31	36	36	2.10	31.0	36	36	36	.70	31.0
17.	3	36	36	1.90	32.0	32	36	36	2.20	31.0	36	36	36	.70	31.5
18.	4	36	36	1.92	32.5	23	36	36	2.40	31.0	36	36	36	.70	31.0
19.	6	36	36	1.82	32.0	27	36	36	2.30	31.0	36	36	36	.70	31.5
20.	6	36	28	1.75	32.0	29	36	36	2.20	31.0	36	36	36	.80	31.5
21.	7	36	24	1.65	32.0	31	36	36	2.30	31.0	36	36	36	.80	31.0
22.	3	36	22	2.02	31.0	33	36	36	*1.00	32.0	36	36	36	.80	31.0
23.	4	36	22	2.05	32.0	34	36	36	1.00	31.0	36	36	36	.80	31.5
24.	7	36	20	1.90	32.0	36	36	36	.90	31.0	36	36	36	.70	31.0
25.	8	36	18	2.00	32.5	36	36	36	.80	31.0	36	36	36	.70	31.0
26	11	36	16	1.97	32.0	36	36	36	.90	31.0	36	36	36	.70	31.5
27.	1	32	15	2.30	32.0	36	36	36	.80	30.0	36	36	36	.70	31.0
28.	1	27	17	2.30	32.0	36	36	36	.80	30.0	36	36	36	.70	31.0
29.	5	22	22	2.55	32.0	36	36	36	.80	31.0	36	36	36	.70	31.0
30.	2	10	24	2.45	31.5	36	36	36	.80	30.0	36	36	36	.70	31.5
31.	4	13	14	2.30	31.5	4	36	36	.80	31.0	......	......	......	......	......

Calculated from 148 feet, height of new dam; formerly calculated from 146.80 feet, height of old dam.

TABLE 2.—*Showing condition of water, etc., for each day in the year, etc.*—Continued.

Day of month.	October, 1886. Condition of water. Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.	Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.	November, 1886. Condition of water. Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.	Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.	December, 1886. Condition of water. Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.	Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.
1.	36	36	36	.70	31.0	36	36	36	.80	31.0	6	4	30	1.30	30.5
2.	36	36	36	.70	31.0	36	36	36	.80	31.0	6	6	24	1.30	31.0
3.	36	36	36	.70	32.0	36	36	36	.70	31.0	6	5	15	1.20	31.0
4.	36	36	36	.70	31.0	36	36	36	.70	31.0	10	5	10	.80	30.0
5.	36	36	36	.70	31.0	36	36	36	.70	31.0	10	6	8	.70	30.5
6.	36	36	36	.70	31.0	36	36	36	.70	31.5	12	6	6	.70	30.0
7.	36	36	36	.70	31.0	36	36	36	.80	33.0	12	12	9	.80	30.0
8.	36	36	36	.70	31.0	36	36	36	.80	32.0	17	18	11	.80	30.0
9.	36	36	36	.70	30.5	36	36	36	.80	31.0	18	21	14	.80	30.5
10.	36	36	36	.70	31.5	36	36	36	.80	31.0	20	20	16	.80	31.0
11.	36	36	36	.70	31.0	36	36	36	.80	31.5	25	26	17	.90	31.0
12.	36	36	36	.70	31.0	36	36	36	.80	31.0	18	26	19	1.00	31.5
13.	36	36	36	.70	31.0	36	36	36	.90	32.0	21	36	22	1.00	31.0
14.	36	36	36	.70	31.0	18	36	36	.90	32.5	24	36	25	1.10	31.0
15.	36	36	36	.70	30.0	14	36	36	.90	32.0	22	36	26	1.10	31.0
16.	36	36	36	.70	31.0	13	30	36	.90	31.5	20	36	28	1.00	30.5
17.	36	36	36	.70	32.0	9	27	36	.90	31.5	20	36	30	.90	30.0
18.	36	36	36	.70	31.0	7	17	36	1.00	31.5	24	36	36	1.00	31.0
19.	36	36	36	.70	31.0	18	24	36	1.00	31.5	13	32	36	1.20	31.5
20.	36	36	36	.70	31.0	23	20	36	1.00	31.5	12	24	36	1.30	31.0
21.	36	36	36	.70	31.0	21	21	36	1.00	32.0	12	10	36	1.40	31.0
22.	36	36	36	.70	31.0	23	36	36	1.00	31.0	8	21	36	1.40	31.5
23.	36	36	36	.70	31.0	19	28	36	1.10	31.0	10	28	36	1.30	31.0
24.	36	36	36	.70	32.0	17	32	36	1.10	31.0	13	30	36	1.30	30.5
25.	36	36	36	.70	31.0	10	31	36	1.10	31.5	7	24	36	1.40	32.0
26.	36	36	36	.70	31.0	6	33	36	1.30	31.0	8	25	30	1.50	32.0
27.	10	36	36	.80	31.0	2	19	36	1.70	31.0	6	28	25	1.50	31.0
28.	11	36	36	.90	31.0	2	11	36	1.90	32.5	6	6	23	1.70	31.0
29.	24	33	36	.80	31.5	3	5	36	1.60	31.0	8	17	20	1.60	30.0
30.	36	19	36	.80	31.0	4	4	36	1.40	31.0	8	14	16	1.40	29.5
31.	36	30	36	.80	32.0	......	......	......	......	......	8	10	14	1.50	30.0

TABLE 2.—*Showing condition of water, etc., for each day in the year, etc.*—Continued

Day of month.	January, 1887.					February, 1887.					March, 1887.				
	Condition of water.			Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.	Condition of water.			Heighth of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.	Condition of water.			Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.
	Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.			Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.			Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.		
1	12	10	13	1.00	30.5	4	6	5	1.50	30.5	3	5	4	2.30	31.0
2	13	15	15	1.10	30.0	4	7	4	1.40	30.5	3	6	4	2.00	31.5
3	14	22	16	1.30	28.5	5	6	4	1.40	31.0	4	8	6	1.80	31.5
4	15	25	18	1.00	28.5	5	6	3	1.40	31.0	3	10	6	1.10	32.0
5	15	25	18	1.00	28.5	3	6	3	1.40	31.0	3	8	6	2.20	32.0
6	20	30	20	1.00	29.0	3	11	3	2.20	31.5	4	9	6	2.00	32.0
7	24	36	25	1.00	29.0	2	14	5	1.00	30.5	4	9	7	2.00	31.5
8	27	36	29	1.00	29.0	7	14	6	1.80	31.0	5	9	7	2.20	31.0
9	29	36	36	1.00	29.5	5	18	6	1.70	31.0	3	10	9	2.40	31.5
10	36	36	36	1.10	29.0	6	16	6	1.60	31.5	3	8	11	2.70	31.5
11	36	36	36	1.00	29.0	7	8	6	1.50	31.0	3	9	12	2.50	32.0
12	36	36	36	1.00	29.5	5	6	6	1.50	31.0	3	10	12	2.50	31.5
13	36	36	36	1.00	29.5	5	9	5	1.40	31.5	5	10	12	2.00	32.0
14	36	36	36	1.00	30.0	5	7	5	1.40	31.0	7	9	12	1.80	31.5
15	36	36	36	1.10	30.0	7	5	6	1.40	31.0	7	11	12	1.70	31.5
16	36	36	36	1.10	30.5	7	5	6	1.30	30.5	7	13	13	1.60	32.0
17	36	36	36	1.00	30.0	9	7	6	1.30	31.0	9	14	17	1.50	32.0
18	36	36	36	1.00	29.5	7	7	6	1.40	31.5	10	15	17	1.40	31.5
19	36	36	36	0.90	29.0	2	8	6	1.60	31.0	10	15	17	1.30	32.0
20	36	36	36	0.90	39.5	1	8	5	2.00	32.0	28	18	17	1.20	32.5
21	36	36	36	1.00	30.0	2	8	5	2.00	31.5	28	20	18	1.20	31.0
22	36	36	36	1.00	30.0	3	5	6	1.70	32.0	29	22	22	1.30	31.5
23	36	36	36	1.10	31.5	4	6	7	1.60	31.5	7	29	36	1.30	31.5
24	30	36	36	1.30	30.5	3	5	7	1.70	32.0	17	24	27	1.20	32.0
25	2	36	36	2.00	30.5	3	5	5	1.60	31.5	23	15	29	1.20	32.0
26	1	36	36	2.40	30.5	3	5	4	1.60	32.0	23	15	28	1.10	31.5
27	2	30	36	3.00	30.5	3	5	4	1.80	33.0	32	16	30	1.00	32.5
28	3	25	28	1.70	30.0	3	4	4	1.80	31.0	25	18	23	1.00	32.0
29	6	7	16	1.40	30.0	......	......	......	......	......	22	10	17	1.00	32.0
30	3	5	10	1.50	31.0	......	......	......	......	......	22	7	16	1.00	32.0
31	3	5	6	1.50	30.0	......	......	......	......	......	28	6	14	1.00	32.0

TABLE 2.—*Showing condition of water, etc., for each day in the year, etc.*—Continued.

Day	April, 1887. Condition of water. Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.	Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.
1	29	6	13	1.00	35.0
2	32	7	12	1.10	32.0
3	36	7	11	1.00	32.0
4	36	9	10	1.10	31.0
5	36	13	10	1.10	31.0
6	36	13	11	1.00	31.0
7	36	13	12	1.00	31.5
8	36	15	12	1.00	31.0
9	36	18	15	1.00	31.0
10	36	23	22	1.00	*24.0
11	36	24	30	.90	*25.0
12	36	27	36	.90	31.0
13	36	32	36	.90	31.0
14	36	36	36	.90	31.0
15	36	36	36	.90	31.5
16	36	36	36	.90	31.5
17	36	36	36	.90	32.0
18	36	36	36	.90	32.0
19	36	36	36	1.00	32.0
20	25	30	36	1.10	31.5
21	10	28	36	1.40	31.5
22	14	28	36	1.50	31.5
23	10	30	36	1.40	32.0
24	10	30	36	1.40	33.0
25	5	25	36	2.50	31.0
26	3	28	36	2.20	32.0
27	4	36	36	1.80	31.0
28	7	36	36	1.80	31.0
29	11	36	25	1.70	31.0
30	9	36	15	1.50	31.0
31	......	......	......	......	......

Day	May, 1887. Condition of water. Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.	Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.
1	11	36	17	1.60	31.5
2	15	36	24	1.60	30.5
3	18	36	18	1.50	31.0
4	21	36	30	1.40	30.5
5	25	36	36	1.30	31.0
6	1	36	36	1.30	31.0
7	3	36	36	1.50	31.0
8	4	36	26	1.70	32.0
9	1	36	22	2.70	31.0
10	1	32	22	2.90	31.0
11	1	12	22	3.00	31.0
12	1	13	20	2.80	30.5
13	2	13	20	1.50	30.5
14	3	15	18	2.10	31.0
15	6	16	15	1.80	31.0
16	10	17	13	1.50	30.5
17	16	17	13	1.40	30.5
18	20	19	15	1.30	30.5
19	27	26	22	1.20	30.5
20	30	32	29	1.20	31.0
21	33	36	36	1.20	30.5
22	34	36	36	1.10	31.5
23	36	36	36	1.00	29.0
24	36	36	36	.90	30.5
25	4	36	36	.90	30.5
26	4	20	36	1.00	30.0
27	2	22	36	1.00	30.0
28	2	18	36	1.10	29.5
29	4	10	36	1.00	31.0
30	9	15	36	1.00	30.5
31	9	19	36	1.00	30.5

Day	June, 1887. Condition of water. Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, affluent gate-house.	Height of water over dam at Great Falls, feet.	Gauge pressure at Rock Creek, pounds per square inch.
1	7	20	36	1.00	30.5
2	8	24	36	1.50	31.0
3	1	24	36	1.40	31.0
4	1	26	36	1.70	30.0
5	2	16	36	1.40	31.0
6	3	9	36	1.30	30.0
7	3	8	36	1.30	30.0
8	1	11	36	1.70	30.0
9	2	12	36	1.80	30.0
10	2	9	36	1.80	30.0
11	3	14	35	1.70	30.0
12	3	8	30	1.60	31.0
13	3	10	33	1.40	30.0
14	4	14	34	1.40	30.0
15	6	14	34	1.30	29.5
16	11	18	36	1.20	29.5
17	18	20	36	1.20	30.0
18	28	26	36	1.10	30.0
19	29	32	36	1.00	30.5
20	33	36	36	.90	30.0
21	36	36	36	.90	30.0
22	33	36	36	.90	30.0
23	10	36	36	1.20	30.0
24	12	19	36	1.30	30.0
25	20	23	36	1.30	28.5
26	8	22	30	1.10	31.0
27	10	20	30	1.00	29.5
28	20	30	36	1.00	30.0
29	30	36	36	.90	29.5
30	34	36	36	.90	29.5
31	......	......	......	......	......

* Break in 36-inch main.

TABLE 3.—(*Compiled from Table 2*) *showing number of days during which the water was clear or turbid at the places indicated.*

Place.	Clear.	Slightly turbid.	Turbid.	Very turbid.
Great Falls	164	29	51	121
Receiving reservoir	227	45	58	35
Distributing reservoir	256	39	32	38

TABLE 4.—(*Compiled from table 2*) *showing number of days in each month in which 9 a. m. (pound) pressures were:*

Month.	Twenty-eight and a half.	Twenty-nine.	Twenty-nine and a half.	Thirty.	Thirty and a half.	Thirty-one.	Thirty-one and a half.	Thirty-two.	Thirty-two and a half.	Thirty-three.	Thirty-five.	Average pressure.
1886.												
July						2	4	19	6			31.6
August				2		18	5	4	1			[illegible]
September			1	3	6	14	6					[illegible]
October				1	1	23	2	4				[illegible]
November						15	8	4	2	1		[illegible]
December			1	8	4	13	3	2				30.7
1887.												
January	3	6	5	9	6	1	1					[illegible]
February					4	12	7	4		1		[illegible]
March						3	12	14	2			[illegible]
April*						13	6	7		1	1	[illegible]
May		1	1	2	13	11	2	1				[illegible]
June	1		5	17	2	5						[illegible]
Total	4	7	13	43	36	130	56	59	11	3	1	[illegible]

*April 10, 24 pounds; April 11, 25 pounds; occasioned by break in 36-inch main.

List of appropriations made for the Washington Aqueduct, with date of act for the same.

Date.	Amount.	Date.	Amount.
September 30, 1850	$500	March 3, 1873[3]	$42,[illegible]
August 31, 1852[1]	5,000	June 23, 1874[4]	[illegible]
March 3, 1853	100,000	March 3, 1875	[illegible]
March 3, 1855	250,000	July 31, 1876	[illegible]
August 18, 1856	250,000	March 3, 1877	15,[illegible]
March 3, 1857	1,000,000	June 20, 1878	15,[illegible]
June 12, 1858	800,000	March 3, 1879[5]	20,[illegible]
June 25, 1860	500,000	June 4, 1880[6]	20,[illegible]
July 4, 1864	150,000	March 3, 1881	20,[illegible]
July 28, 1866	142,581	July 1, 1882[7]	20,[illegible]
December 20, 1866	12,000	March 3, 1883	20,[illegible]
March 2, 1867	20,000	July 5, 1884	20,[illegible]
July 25, 1868	52,500	February 25, 1885	20,[illegible]
March 3, 1869	25,000	July 9, 1886	20,[illegible]
July 15, 1870[2]	120,822	March 3, 1887	20,[illegible]
March 3, 1871	114,196		
June 10, 1872	70,555	Total	3,965,1[illegible]
January 23, 1873	14,000		

NOTE.—Reverted to the Treasury, [1]$2.81, [2]$46.25, [3]$560.87, [4]35 cents, [5]$1,109.87, [6]$381.06, [7]$1,354.17; total, $3,455.38. The balance, $3,961,701.62, being the amount expended to June 30, 1887. Since 1878 one-half of the amounts appropriated have been contributed by the United States and the other half by the District of Columbia.

The money statement for the year ending June 30, 1887, is as follows:

Amount appropriated by act of July 9, 1886		$20,000.00
Amount appropriated by act of March 3, 1887		20,000.00
		40,000.00
Amount expended during the year	$15,666.38	
Outstanding liabilities June 30, 1887	4,333.62	
		20,000.00
Balance available June 30, 1887		20,000.00

The amount required for engineering, maintenance, and repairs of the Washington Aqueduct, and its appurtenances, for the year ending June 30, 1889, is $20,000. This sum, as shown by long experience, is only

sufficient for the annual maintenance and current repairs of the aqueduct. But in order to insure the water supply against any danger of pollution, and to allay the fears of the community in that respect, it is highly desirable that means should be provided for making certain improvements at the Great Falls and receiving reservoir, as urged in my last two annual reports; these improvements provide for intercepting and diverting streams and surface drainage which now enter the receiving reservoir, for dredging the reservoir and for riprapping its banks; it is also desirable to acquire and fence in a few small tracts of land in the vicinity of the reservoir, and of the inlet to the aqueduct at the Great Falls, which are now occupied by private parties in such way as to give rise to fears concerning the purity of supply. The cost of the proposed work (the details of which will be found in my annual report for 1885) will be about $125,000. The law requires that the sum necessary for the annual maintenance and repairs of the aqueduct shall be included in the estimates submitted to Congress annually by the Commissioners of the District of Columbia, and the appropriation has, for a number of years past, been included in the bill for the support of the District; but I do not understand that an estimate for *new* work in relation to the water supply has any connection with the annual estimates of the Commissioners.

I would therefore recommend that the Commissioners be advised that the sum estimated as necessary for "engineering, maintenance, and repairs of the Washington Aqueduct for the year ending June 30, 1889," is $20,000. Also that an additional estimate of $125,000 be submitted to Congress by the War Department, as an item of the sundry civil bill, for improving the water supply of Washington, D. C., by intercepting and diverting the flow of surface waters and streams tributary to the receiving reservoir, dredging the reservoir and paving its banks, and by controlling the surface drainage near the inlet to the aqueduct at the Great Falls of the Potomac.

VV 2.

INCREASING THE WATER SUPPLY OF WASHINGTON, DISTRICT COLUMBIA.

This work was inaugurated in obedience to an act of Congress approved July 15, 1882, and involves as it sessential features—(1) raising the dam in the Maryland Channel at the Great Falls of the Potomac, to an elevation of 148 feet above mean high tide at the Washington navy-yard, and its extension at that height across Conn's Island and the Virginia Channel of the river; (2) extending the Washington Aqueduct from the distributing reservoir, near Drover's Rest, to the site selected for the new reservoir, near Howard University; the plan adopted for this extension being a tunnel under pressure 20,700 feet long; (3) constructing at the tunnel outlet, a reservoir of about 300,000,000 gallons, capacity; (4) connecting the new reservoir with the existing system of water mains in the city of Washington by new line of large mains.

Operations during the past fiscal year have been chiefly on the tunnel and reservoir, the dam having been finished early in the year (August 21, 1886), and the new mains laid up to the site of the reservoir in 1885.

The following is an outline of the history of operations during the year, and further details are given in the report of Lieut. C. McD. Townsend, Corps of Engineers, submitted herewith:

DAM AT THE GREAT FALLS.

At the beginning of the year this work required the placing of only 192 linear feet of coping for its completion. This was accomplished without difficulty, and the contract closed August 21, 1886.

The total length of the dam as now completed is 2,877 feet; of this length 1,034 feet is comprised in the old dam closing the Maryland Channel, which was raised to the designated height by placing a coping 15 inches thick. The next stretch of dam crosses Conn's Island, and is 669 feet long; the remaining 1,174 feet closes the Potomac Channel. The new part of the dam varies from 4 to 20 feet in height.

The final estimate of work done by the contractors was as follows:

1,086.3 cubic yards coping masonry, at $24.50	26,614.35
1,989.7 cubic yards cut-stone masonry, at $20.75	41,286.27
2,820 cubic yards concrete masonry, at $5.50	15,510.00
889 cords riprap backing, at $7.25	6,445.25
34,166 pounds wrought-iron drift bolts and cramps, at 7 cents	2,391.62
5,695 cubic yards excavation, at $1	5,695.00
9,500 square yards area cleared, at 5 cents	475.00

EXTRA MATERIAL AND LABOR.

224 cubic yards concrete masonry, at 50 cents	112.00
40 barrels Portland cement, at $2.70	108.00
1 barrel Portland cement, at $3.75	3.75
124.5 barrels Cumberland cement, at $1.15	143.17
75 cement sacks, at 15 cents	11.25
27.57 yards coarse sand, at $1.20	33.08
2 yards fine sand, at 60 cents	1.20
3 yards clay, at $1.25	3.75
531.38 square feet fine pointing, at 30 cents	159.41
34 linear feet stop-notches, at $3.50	119.00
Pay-roll for services in July, 1885	396.92
Making deflecting-dams, coffer-dams, sluices, and all other work required, as per supplemental contract	15,000.00
Total	114,509.02
Work, etc., under original contract	98,417.49
For extra work and material	1,091.53
Supplemental contract	15,000.00
Total paid contractors	114,509.02

Of the above amount the sum of $3,216.47 only was for work done during the past fiscal year. The amount expended from the beginning on account of surveys, engineering, superintendence, contingencies, etc., is $10,976.46.

The original appropriation was		$145,151.00
Deduct amount paid contractors	$114,509.02	
Deduct expenses of surveys, engineering, etc	10,976.46	
		125,485.48
Balance on hand		19,665.52

There was also appropriated a sum of $45,000, to pay for land and water rights at the Great Falls, but these matters are pending in court in charge of the Attorney-General. No expenditure was made on account of this appropriation during the year, and in all only $117.96 has been expended therefrom, as stated in previous reports.

TUNNEL FOR AQUEDUCT EXTENSION.

At the beginning of the fiscal year no work was in progress, operations having been suspended February 1, 1886, when the original appropriation for the work became exhausted; at that time the tunnel had been excavated through a length of 18,538.2 feet, of which 1,489.66 feet had been lined, the lining consisting of a facing of brick masonry laid in hydraulic cement mortar, with a backing of concrete for the invert and side walls, and a packing of dry stone, carefully placed, to fill in the space comprised between the arch and the rock through which the tunnel was excavated.

The suspension of operations continued until after the passage of the general deficiency bill approved August 4, 1886, which contained an appropriation of $395,000 for completing the tunnel. This appropriation was made after prolonged investigation by the House Committee on Appropriations, as the result of criticisms in which the method of doing the work, especially the character of lining, was fiercely assailed. Full record of this investigation is found in H. R. Report No. 3109, Forty-ninth Congress, first session, of which 70 pages out of 84 are devoted to this subject. As a result of this investigation the committee reported that it was not convinced that a mistake had been made in the plans adopted for lining the tunnel, "but recognizing the difficulty, the novelty, and the importance of these questions and the expediency of submitting them to competent experts (the committee) have, in recommending the amount called for by the estimates, provided that the Secretary of War shall forthwith take the advice of the highest Engineer Board of the Army upon the plans and methods heretofore pursued." Accordingly the appropriation of the amount called for was coupled with the conditions that the Secretary of War should "submit to the Board of Engineers for Fortifications and for River and Harbor Improvements whether any changes are demanded for reasons of safety or economy in the method of lining said tunnel heretofore adopted and pursued, and whether any changes are required in the method of lining and perfecting the reservoir: *Provided*, That said board shall make full report thereon, and pending such examination the work shall proceed upon such parts thereof as the Secretary of War shall direct. The work above provided for to be done under the contract heretofore made or by a reletting, as in the discretion of the Secretary of War shall be most promotive of the interest of the Government."

In pursuance of this legislation it was determined to continue the work of excavation under the original contract (see copy of correspondence herewith), and this part of the work was resumed August 30, 1886, and continued without interruption until the close of the fiscal year, when the tunnel was "holed" through. The work of excavation remaining to be done after that date was only such as will be required from enlarging and trimming to the requisite lining or normal cross-section.

In the mean time the matters in question were promptly submitted to the Board of Engineers, as directed by Congress, and after careful examination and personal inspection of the tunnel the Board made its report thereon August 24, 1886, a copy of which was received by me from the Secretary of War August 27, 1886. In this report the Board concluded that the exclusive use of concrete for lining (as had been urged in the strictures against the method formerly adopted) was impracticable, indorsed the use of the brick arch as then being constructed, but recommended that the filling between this arch and the rock in place be done "with rubble laid in cement mortar, or with fine concrete

packed solidly around larger stones according to convenience," instead of with dry-stone packing. After careful deliberation (see correspondence herewith) supplemental articles of agreement were entered into with the contractors on the work, providing for the use of rubble masonry, no provision for that class of work having been made in the original contract. The cost of packing or filling was thereby increased from $2.50 to $4.75 per cubic yard. Operations on the work of lining were then resumed, and the total length of tunnel lined up to the close of the fiscal year was 6,110.5 feet. Operations during the year were conducted without loss of life or serious accident of any kind.

The total estimate of work done by the contractors on the tunnel up to June 30, 1887, is as follows:

73,551 cubic yards excavation in tunnel, at $8	$588,408.00
2,148.75 cubic yards earth excavation in shafts, at $6	12,892.50
2,676 cubic yards rock excavation in shafts, at $10	26,760.00
7,828 cubic yards brick masonry in tunnel, at $14	109,592.00
2,014 cubic yards concrete masonry in tunnel, at $5	10,070.00
4,936.72 cubic yards dry-stone packing in tunnel, at $2.50	12,341.80
383 cubic yards brick masonry in shafts, at $18	6,894.00
600 cubic yards concrete masonry in shafts, at $5	3,000.00
930 cubic yards dry-stone packing in shafts, at $2.50	2,325.00
444 linear feet air-shafts complete, at $15	6,660.00
637.78 cubic yards extra excavation in tunnel, at $1.50	956.67
10,178 cubic yards rubble masonry in tunnel, at $4.75	48,345.50
Total for contract work	828,245.47
Paid contractors for pumping	7,035.00
Total cost of work done	835,280.47
Deduct 10 per cent. retained on contract work	82,824.54
Amount paid contractors	752,455.93

Of the above total the sum of $261,110.81 is for work done during the past fiscal year.

In addition to the above total there have been expended from the appropriations for aqueduct extension the following sums:

For west connecting conduit (1886)	$5,005.58
Engineering, superintendence, and contingencies, including cost of preliminary surveys and examinations (1882-1887)	35,410.80
Total	40,416.38

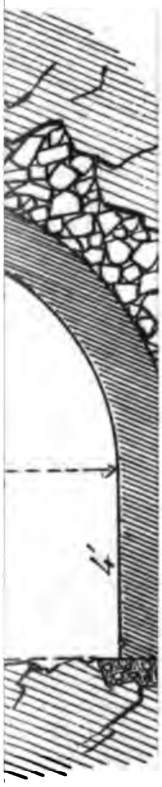
This, added to the total cost of work done by the contractors, makes the grand total of expenditures up to June 30, 1887, including outstanding liabilities and retained percentages, $875,696.85.

The appropriations have been as follows:

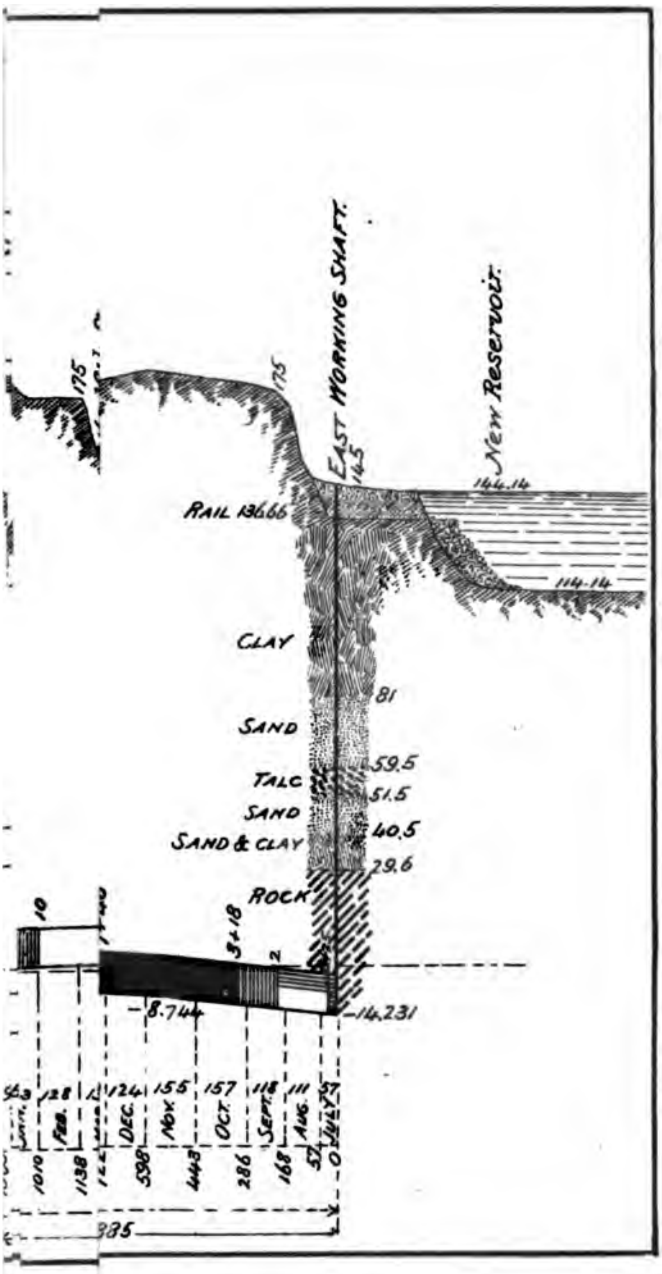
Act approved July 15, 1882	$599,534.55
Act approved March 26, 1886 (pumping)	5,000.00
Act approved August 4, 1886	395,000.00
Total appropriated	999,534.55

Deducting therefrom the total expenditures and liabilities ($875,696.85) to June 30, 1887, the balance available at that date was $123,837.70.

The estimate on which the deficiency appropriation of $395,000 was made in 1886 was prepared in the summer of 1885, when but little more than one-half the length of the tunnel had been excavated, and therefore the character of rock to be encountered in the then unopened parts was purely a matter of surmise. This estimate assumed that only about one-half the tunnel would require lining. Again, this estimate presumed the use of dry-stone packing as comprising the most considerable part



valls.



East Working Shaft.
145
New Reservoir.
175
175
144.14
114.14
Rail 136.66
Clay
81
Sand
59.5
Talc
51.5
Sand
40.5
Sand & Clay
29.6
Rock
10
3+18
2
-8.744
-14.231
Dec.
Nov.
Oct.
Sept.
Aug.
July
Feb.
128
124
155
157
118
111
57
1010
1138
598
443
286
168
57
0
385

the lining; but, as before shown in this report, we are required to ›stitute rubble masonry, at an increased cost of $2.25 per yard—an in- ase of 90 per cent. It was also assumed that the money required to ry on the work would be supplied in time to prevent any suspension operations, but such was not the case.

After work was resumed it soon became evident that the extent of nel calling for lining had been underestimated, and, in fact, nearly the rock penetrated since that time is such as to make lining unques- nably necessary; besides, a considerable quantity of rock that was nsidered firm and compact when the estimate of 1885 was made has ice then developed imperfections and elements of weakness such as seriously threaten the stability of the tunnel if left unprotected by ing. Thus we now find it important to submit an estimate involving e lining of a much greater length of tunnel than was before contem- ated, and at a higher price to the extent of the difference in cost be- een rubble masonry and dry-stone packing.

The original estimate made provision for lining 10,893 feet of the tun- l, while in that now submitted this length is increased to 15,325 feet; t the original estimate proposed lining the entire cross-section of the nnel, with invert, side wall, and arch wherever any lining at all was aced, whereas the method now proposed is to vary the lining accord- g to the character of the rock, with a view to reducing the cost of ing to minimum. Thus of the 15,325 feet which it is now proposed to e, it is estimated that 8,025 feet should have the full lining, 2,900 feet here the lining will consist of arch and side walls, and 4,400 feet of ch only.

The total estimated cost of the tunnel now submitted is $1,181,582.55. he amount already appropriated is $999,534.55; whence, on a close stimate, it appears that an additional appropriation of $182,048 is re- ired to complete the work. But I would urge that the amount of the propriation be made $200,000, in order that we may be prepared for nseen emergencies, and thereby avoid any further delay in completing e work. The details of the new estimate will be found in the report f Lieutenant Townsend, which is transmitted herewith.

The completion of the tunnel as now proposed involves the least mount of lining compatible with the security of the work; it is a seri- us question, however, whether we should not go further and arch all e rest of the tunnel in order to provide against any possible danger f its becoming blocked by a fall of rock from the roof, such as might come time through the development of faults or elements of weakness that re not now perceptible. To do this will cost about $120,000, in addition the estimate submitted above. I am of the opinion that, in considera- on of the great importance of doing everything possible to insure e stability of the work, it would be a wise economy to increase the ppropriation to $320,000 for this additional element of security.

When the water supply is finally passed into the tunnel, and the ities have become dependent upon it, any accident that might call for recurrence to the present inadequate system of supply would cause erious trouble, if not absolute distress in certain sections. For this eason I am inclined to the opinion that it may be well to let the tunnel ll with water when the money now available is exhausted, and pump t out after the new appropriation becomes available, thereby making ctual test of the stability of the work before the community becomes ependent upon it for its water supply. At the same time I can not rge too strongly an appropriation, at the earliest possible date, of the ull amount now estimated as necessary for completing and realizing

the advantages of this great work, which affects so closely the comfort and health of nearly 200,000 people in this District.

NEW RESERVOIR.

The progress made by the contractors on the reservoir during the past fiscal year has been slow and entirely unsatisfactory, the working force having been entirely too small as a rule, and the plant insufficient and in poor condition.

At the beginning of the year 727,000 cubic yards of earth had been excavated; the mean elevation of the dam was 153.7 or 6.3 feet below grade; the intercepting masonry conduits had been built for an aggregate length of 3,679 feet; the slope paving of the dam had been completed, also the paving of the east slope of the reservoir, and 255 feet in length of the west slope. During the year 101,186 cubic yards were excavated, and the dam thereby practically completed; the intercepting conduits have been completed; the slope paving on the west and north was extended over a length of 1,994 feet, and 942 feet of road gutters were graded and paved. For the purpose of paving, 6,810 cubic yards of stone had to be hauled from the tunnel dumps at Champlain avenue, Rock Creek, and Foundry Branch, that taken from the tunnel at the Howard University shaft having been soft and unfit for use.

The original appropriation ($431,273.75) for this work was exhausted in the early part of the fiscal year, but the general deficiency act approved August 4, 1886, appropriated the additional sum of $160,000 to complete the reservoir, making the same conditions in relation to its expenditure as applied to completing the tunnel, all of which are fully set forth in that part of this report relating to that work. The Board of Engineers therein referred to was required to determine whether any "changes are required in the method of lining and perfecting the reservoir," and reported thereon as follows:

"The inspection of the new reservoir satisfied the Board that the work is proceeding in an entirely satisfactory manner, as proposed by the special Board of 1885, and this Board has no changes to recommend."

The act of appropriation provided that the work should be continued "under the contract heretofore made or by a reletting, as in the discretion of the Secretary of War shall be most promotive of the interests of the Government." Careful consideration having been given to this matter, it was finally determined to continue the work under the original contract (see correspondence in relation thereto accompanying the report), and to this end that contract was extended to December 31, 1886, and again to June 30, 1887, which was the date fixed for completing the work. This the contractors failed to do, however, and the contract has been finally extended to October 31, 1887, at which time it is believed the contractors will have completed what is required of them, comprising as its principal features about 25,000 cubic yards of excavation, 9,500 square yards paving, 20,000 square yards sodding, besides trimming and cleaning the slopes and bottom of the reservoir to their true planes and grades.

After this is done the construction of the gate-house, with its distributing conduits on the bed of the reservoir and its connection with the effluent 75-inch main, will put the reservoir in condition to receive the water supply. This can all be accomplished with the present appropriation during the current fiscal year, and before the completion of the tunnel by which the water supply is to be brought to the reservoir. At this writing it does not appear that any additional appropriation

will be required for completing the essential features of the work, but it is likely that additional money will be needed to properly finish up the grounds about the reservoir. No appropriation for this purpose is asked for at this time, but it may be made the subject of a special communication at a later date.

The total estimate for work done by the contractors up to June 30, 1887, is as follows:

Items.	Work done.				
	To June 30, 1886.	During year ending June 30, 1887.	Total.	Price per yard, etc.	Cost.
Excavation ....cubic yards..	727,329	101,186	828,515	$0.30	$248,554.50
Puddling ....do....	59,106	2,011	61,117	.40	24,446.80
Cut-stone masonry ....do....	2½	2	4½	15.00	67.50
Brick masonry ....do....	736	194	930	9.00	8,370.00
Concrete masonry ....do....	8,520	1,170	9,690	5.50	53,295.00
Rubble masonry ....do....	86	18	104	6.00	624.00
Trap-rock lining ....square yards..	4,367	710	5,077	1.00	5,077.00
Broken-stone lining ....cubic yards..	7,078	3,099	10,177	2.00	20,354.00
Paving ....square yards..	39,414	13,276	52,690	.28	14,753.20
Coping ....linear feet..	....	40.9	40.9	5.00	204.50
Cast-iron drains ....do....	276	106	382	.75	286.50
Pine plank ....M. feet, B. M..	46,431	43,602	90,033	30.00	2,700.99
Total	....	....	....	....	378,733.99
Less 10 per cent. retained	....	....	....	....	37,873.40
Amount paid contractors	....	....	....	....	340,860.59

Of the above total $51,696.54 is for work done during the past fiscal year. In addition there has been expended for stone, trap rock, and brick furnished to contractors $41,024.59, and for surveys, engineering, contingencies, etc., since the beginning, the sum of $54,547.51, making the total expenditures, including retained percentages and outstanding liabilities to June 30, 1887, $474,306.09. The appropriations have been as follows:

Act of July 15, 1882	$431,273.75
Act of August 4, 1886	160,000.00
Total	591,273.75
Deducting therefrom the total of expenditures and liabilities, the balance available for continuing and completing the work at the close of the fiscal year was	116,967.66

LAND FOR AQUEDUCT EXTENSION AND RESERVOIR.

The only payment made on account of land during the year was that of June 6, to Robert Proctor, for $62, and recording deed of the same, $1.50—total $63.50, on account of land to extend aqueduct. All previous payments are given in the annual reports of the Chief of Engineers for 1885 (pages 2476 and 2477) and 1886 (pages 2059 and 2060).

The balance available for land at the close of the fiscal year was as follows:

For "land to extend aqueduct"	$25,007.99
For "land for reservoir"	814.28

MAIN CONNECTIONS.

The only work done on the main connections during the year was the calking of the 75-inch outlet main from the new reservoir, which was done between January 19 and February 28, 1887.

The total amount expended on account of main connections t
30, 1887, was as follows:

For water-pipe, valves, and special castings.	$12
For pay-rolls for labor, superintendence, etc	2
For materials, tools, supplies, etc	1
For hauling pipe from depots, etc	[illegible]
Total	16

of which the sum of $838.90 was applied during the past fisca
The original appropriation was $165,400, and the balance now
ble is $2,008.58, which will probably suffice to complete this part
work by making proper connection with the gate-house when bu

The following is an abstract of contracts for increasing the wat
ply of Washington, D. C., in force during the fiscal year ending
30, 1887:

For dam.—Chittenden Brothers, of Washington, D. C., contra
date of contract, November 7, 1883; date of supplemental co
March 4, 1884. These contracts were completed August 21, 188

For tunnel.—Beckwith & Quackenbush, of Mohawk, N. Y., co
ors; date of contract, October 29, 1883; date of supplemental co
October 18, 1886. These contracts expired June 30, 1887, but hav
extended to November 30, 1887.

For reservoir.—Maloney & Gleason, of Washington, D. C., con
ors; date of contract, October 30, 1883; expired June 30, 188
tended to October 31, 1887, subject to monthly forfeit of $300 per
during period of extension.

The following is a money statement for the fiscal year ending
30, 1887:

Title of appropriation.	Amount unexpended July 1, 1886.	Expended during the year.	Amount unexpended June 30, 1887.	Outstanding liabilities, including retained percentages.	A ava June
Land to extend aqueduct	$25,071.49	$63.50	$25,007.99	....	$2
Extension of aqueduct	*395,000.00 56,993.00	210,215.76	241,777.24	$117,939.54	12
Main connections	2,847.48	838.90	2,008.58	....	
Land for reservoir	814.28	....	814.28	....	
Constructing reservoir and gate-house	*160,000.00 71,610.93	71,964.34	159,646.59	42,678.93	11
Water rights and land to extend dam at Great Falls	44,882.04	....	44,882.04	....	4
Completion and extension of dam at Great Falls	36,548.93	16,883.41	19,665.52	....	1
Preventing tunnel from flooding and other injury	1,380.00	1,380.00	....	....	......
Aggregate	795,148.15	301,345.91	493,802.24	160,618.47	33

* Appropriated by Act of August 4, 1886.

CORRESPONDENCE RELATING TO THE TUNNEL.

GEORGETOWN, D. C., *June* 24, 1

SIR: We desire an extension of the time named in our contract for the com
of the Washington Aqueduct tunnel to June 30, 1887, and we offer as reasons wh
an extension should be made the following:

(1) Increased depth of shafts.
(2) Difficult and bad ground not anticipated.
(3) Delay to work caused by necessity of lining tunnel close to headings.
(4) Stoppage of work by order of Capt. T. W. Symons, dated January 28,
since which time work has practically been suspended, except pumping to kee
nel free from water.

'e believe that the work can not be entirely completed very much in advance of time asked, because the tunnel yet remaining to be driven, about 2,100 feet, is a Champlain avenue heading extremely bad, and from the Howard University ding very heavy and treacherous ground, necessitating timbering and lining close in order to insure its safe and successful prosecution.

Ve respectfully ask that an early decision be made in this matter.

Yours, respectfully,

BECKWITH & QUACKENBUSH.

+. J. LYDECKER,
Major Engineers, U. S. A., and Engineer in charge Washington Aqueduct.

[First indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, June 25, 1886.

Respectfully forwarded to the Chief of Engineers, U. S. A.

Ignoring the grounds on which the application for the extension of time is based, I ould state that Congress has made no provision for continuing the work, and there-e I can not make the extension of time as requested.

The importance of appropriating the money required for completing the tunnel stimated at $395,000) was urged in my last annual report, and subsequently in a ter dated December 15, 1885, which was duly transmitted to Congress by the hon-able Secretary of War, dated January 15, 1886 (H. R. Ex. Doc. 39).

The principal points involved in this matter are briefly stated as follows: The con-actors, by contract dated October 29, 1883, undertook to construct a tunnel "20,826 et long, more or less," and to *complete the work* "on or before June 30, 1885." The time completion was extended to June 30, 1886, but by the end of January, 1886, the oney available for the prosecution of the work had been reduced to about $1,500, hereupon active operations were suspended, and the contractors instructed to limit emselves to keeping the tunnel clear of water. A special appropriation of $5,000 r continuing pumping operations was made by Congress in the bill approved March , 1886, and this money will all be exhausted by or about the 30th instant. After that te, therefore, there will be no funds of any nature whatever applicable to this work nless Congress should in the intervening few days make suitable provision.

The estimated cost of completing the tunnel, prior to the suspension of active oper-tions, was $395,000, but it is probable that the ultimate cost will be increased by ason of this suspension, which has lasted since February 1, 1886, a period of five onths.

G. J. LYDECKER,
Major of Engineers.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 9, 1886.

SIR: The act making appropriations to supply deficiencies in the appropriations for the fiscal year ending June 30, 1886, etc., approved August 4, 1886, under the head-ing "Increase of water supply, Washington, District of Columbia," makes provision for completing the tunnel and reservoir, and directs that certain questions connected therewith be submitted to the Board of Engineers for Fortifications and for River and Harbor Improvements (copy of the act herewith).

A copy of the letter to the Secretary of War in reference to the questions to be sub-mitted to the Board, as provided for in the act, is herewith, for your information.

In connection with this subject your attention is invited to the proviso on page 11, in reference to proceeding upon such parts of the work as the Secretary of War shall direct pending the examination to be made by the Board.

You will please submit a project for the application of the whole amount appro-priated, as well as for such parts of the work as in your judgment may properly be carried on pending action upon the report of the Board.

By command of Brigadier-General Newton.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Maj. G. J. LYDECKER,
Corps of Engineers.

LETTER OF THE CHIEF OF ENGINEERS TO THE SECRETARY OF WAR.

OFFICE OF THE CHIEF OF ENGINEERS,
U. S. ARMY,
Washington, D. C., August 9, 1886.

SIR: The act making appropriations to supply deficiencies, etc., approved August 4, 1886, under the heading "Increase of water supply, Washington, District of Columbia," after making appropriations for completing the work, directs that certain questions in connection with the tunnel and reservoir be submitted to the Board of Engineers for Fortifications and for River and Harbor Improvements for investigation and report (pages 10 and 11 of copy of act herewith).

It is recommended that the Board be directed to convene in this city for the above purpose at the earliest day practicable.

If the above meets approval the requisite orders and instructions will be issued from this office.

A copy of the act will also be furnished Maj. G. J. Lydecker, Corps of Engineers, with instructions to submit a project for the application of the money appropriated, with his recommendation as to the manner in which it is to be applied under the law. He will also be instructed to furnish the Board with all information in his possession touching the questions submitted to the Board, and every facility that the members may deem necessary to enable them to fully understand the subject committed to them.

Very respectfully, your obedient servant,

JOHN NEWTON,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. WM. C. ENDICOTT,
Secretary of War.

LETTER OF MAJOR G. J. LYDECKER, CORPS OF ENGINEERS.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., August 11, 1886.

SIR: Referring to your instructions of the 9th instant, I have the honor to submit below a project for the expenditure of such part of the sum of $555,000, appropriated in the general deficiency act approved August 4, 1886, under the heading "Increase of water supply, Washington, District of Columbia," as relates to the tunnel.

Of the sum above named $395,000 is appropriated "to complete the tunnel." To this end I submit that the work of excavation and removal of excavated material from the tunnel be resumed at once, under the contract heretofore (October 29, 1883) made with Messrs. Beckwith and Quackenbush, but that no further work be done on the lining until after final action upon the report of the Board of Engineers as to "whether any changes are demanded for reasons of safety or economy in the method of lining said tunnel heretofore adopted and pursued." If, in pursuance of such action, it should be determined to continue substantially the present method of composite lining (of brick, concrete, and dry stone), or to make the lining of brick and concrete only, using little or no dry stone, then, in either of these cases, the work of lining should also be resumed and completed under the aforesaid contract with Beckwith and Quackenbush. If, on the contrary, it should be determined to adopt a method of lining radically different from the foregoing, it would be necessary to make a separate contract for that part of the work. The course above outlined is, in my judgment, that "most promotive of the interests of the Government." These contractors have in place a large and complete plant with which the work of excavation can be immediately commenced; their price for excavation is fair and reasonable, and is undoubtedly less than that at which any responsible bidder would undertake the comparatively small length of tunnel remaining to be excavated, this length being about 2,150 feet—that already excavated being 18,538 feet, or a little over 3½ miles. They have proven themselves to be most expert in their work, energetic, ready at all times to do everything required of them under their contract without cavil or dispute, and by their long experience on this particular work they are better qualified to carry it on than strangers would be; also, the work specified to be done under their contract is the construction of a tunnel "from the present distributing reservoir above Georgetown to the proposed new reservoir east of Howard University," and if other contractors should be put on the work to complete it, it is not unlikely that we would become involved in troublesome and expensive litigation, and possibly in delays arising from injunctions, in addition to such as would certainly come from the substitution of a new working plant, organization of a new working force, and its initiation on the work.

My recommendation in relation to this work is, therefore, that the contract with Beckwith and Quackenbush be extended to June 30, 1887, and that the work be re-

ed at once, with the understanding that operations under said contract be limited he work of excavation and the removal of excavated material from the tunnel, l a final determination of the method of lining the tunnel is arrived at; the tion as to whether this lining shall be done (1) under the contract aforesaid, (2) er said contract modified to meet the requirements of the case, or (3) by a relet- — to remain in abeyance until after action upon the report of the Board of Engineers. The work of excavation as herein recommended can properly be carried on ling such action.

he project for work on the reservoir, for which the act hereinbefore referred to appriates $160,000, relates to a separate work, prosecuted under a separate contract, involves entirely different and independent considerations. In order that action elation to work on the tunnel, which is of the more pressing importance, may not unnecessarily delayed, I have forwarded this communication at once, and will plete and forward my project for the reservoir in a separate letter to-morrow.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Major of Engineers.

rig. Gen. JOHN NEWTON,
Chief of Engineers, U. S. A.,

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 18, 1886.

IR: The following indorsements on the letter of Beckwith & Quackenbush of June 1886, requesting an extension of time to June 30, 1887, for the completion of their ntract for Washington Aqueduct tunnel, transmitted to this office by your indorsent of June 25, 1886, submitted with your letter of August 11 to the Secretary of ar, are sent for your information:

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
August 12, 1886.

Respectfully returned to the Secretary of War. Attention is invited to the inclosed tter submitted by Major Lydecker, and to the provisions of the deficiency act aproved August 4, 1886.

Major Lydecker's views and his proposition for continuing the work are recomended for approval, the contract with Messrs. Beckwith & Quackenbush to be exnded to June 30, 1887.

JOHN NEWTON,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

[Fifth indorsement.]

WAR DEPARTMENT, *August* 17, 1886.

Approved as recommended by the Chief of Engineers.
By order of Acting Secretary of War.

SAML. HODGKINS,
Acting Chief Clerk.

By command of the Acting Chief of Engineers.
Very respectfully, your obedient servant,

H. M. ADAMS,
Captain of Engineers.

MAJ. G. J. LYDECKER,
Corps of Engineers.

LETTER OF MAJ. G. J. LYDECKER, CORPS OF ENGINEERS.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., August 19, 1886.

GENTLEMEN: I have the honor to inform you that in accordance with instructions his day received your contract for the construction of the tunnel extension of the Vashington Aqueduct, made October 29, 1883, is, with the approval of the honorable

Secretary of War, extended to June 30, 1887, "with the understanding that operatio under said contract be limited to the work of excavation and the removal of exc vated material from the tunnel until a final determination of the method of lini the tunnel is arrived at, the question as to whether this lining shall be done (1 under the contract aforesaid, (2) under said contract modified to meet the requir ments of the case, or (3) by a reletting to remain in abeyance until after action upo the report of the Board of Engineers."

Please acknowledge receipt.

Very respectfully,

G. J. LYDECKER,
Major of Engineers.

Messrs. BECKWITH & QUACKENBUSH,
Contractors, Washington, D. C.

ORDER CONVENING BOARD OF ENGINEERS.

HEADQUARTERS CORPS OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C. August 12, 1886.

[Special orders No. 111.]

By direction of the Secretary of War, the Board of Engineers for Fortifications and for River and Harbor Improvements, consisting of—

Col. James C. Duane, Corps of Engineers,
Lieut. Col. Henry L. Abbot, Corps of Engineers,
Lieut. Col. Cyrus B. Comstock, Corps of Engineers,
Lieut. Col. David C. Houston, Corps of Engineers,
Lieut. Col. Walter McFarland, Corps of Engineers,

will convene in this city as soon as practicable, upon the order of the senior member to investigate and report upon certain questions in connection with the tunnel and reservoir, as provided for under act of Congress approved August 4, 1886, for the "Increase of water supply, Washington, D. C."

Upon completion of the duties assigned them, the members of the Board will return to their proper stations.

The journeys required under this order are necessary for the public service.

The expenses of the Board will be paid by Maj. Garret J. Lydecker, Corps of Engineers, from the appropriation for increasing the water supply, Washington, D. C.

By command of Brig. Gen. Newton:

JOHN M. WILSON,
Lieut. Col. of Engineers,
Colonel, U. S. A.

REPORT OF BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENINEERS FOR FORTIFICATIONS
AND RIVER AND HARBOR IMPROVEMENTS, ETC.,
Army Building, New York, August 24, 1886.

GENERAL: The Board of Engineers for Fortifications and for River and Harbor Improvements has the honor to report that pursuant to your instructions of August 12, 1886, it met in Washington, August 17, at Major Lydecker's office, and assisted by that officer, and by Mr. Coryell, the Superintendent, made an examination of the maps and records bearing upon the subjects on which it is required to report by the deficiency act approved August 4, 1886. On August 18 it made a personal examination of the tunnel, in company with Major Lydecker, entering by the Champlain avenue working shaft, and examining in the west drift some of the worst rock encountered in the whole tunnel, and in the east drift some of the best. Major Lydecker states that these extremes, with the intermediate grades inspected, will afford a fair idea of the variations in the character of the work to be done. The Board

n proceeded to the site of the new reservoir near the Soldiers' Home, l made an inspection of its present condition and of the methods em-yed in its construction.

A second meeting was held at Major Lydecker's office, at which ptain Symons, Corps of Engineers, until recently in immediate su-vision of the work on the tunnel, was present and the whole subject s minutely discussed.

The following conclusions of the Board have been reached from in-mation thus obtained and after closely considering H. R. Report No.)9, Forty-ninth Congress, first session, with the documents appended ereto:

The Board indorses the use of brick in the lining of the tunnel. The clusive use of concrete, in its opinion, is impracticable.

The character of the rock encountered in this tunnel is unfavorable endurance from its tendency to deteriorate when exposed to the air. some places this change has already occurred; at others, rock which ien blasted is sound and hard will sometime remain so, while that cavated only a few feet away will in a few months crumble almost to clay. Iron pyrites is often detected, and analysis indicates that it not the only cause of the trouble. Impure mica, magnesium silicate a talcose form, and perhaps other causes of degeneration, are present. ıe headings were started from the different shafts in sound rock giv-g no indication of the probable presence of this disintegrating rock on e line of the tunnel, and there appears to be no reason why better re-lts should have been anticipated by carrying the shafts and the tun-ıl any lower. If the bad character of the rock had been anticipated, e grade of the tunnel would have been fixed much higher. The work ıs now advanced too far for any change in grade to be practicable, and only remains to make suitable provision to resist the hydraulic pres-ıres to be apprehended.

Where the rock is solid and can safely be trusted to resist disinte-ration, which the engineer in charge judges from present appearances ill be the case for about four-tenths of the length of the tunnel, no ning is necessary and no change in the present cross-section is sug-ested.

Where the rock, although fairly good, is unsafe to trust without lining, ıe present plan is to line with a 13-inch (3 brick) arch and fill in solidly ith dry stone between the bricks and the rock in place. The Board ecommends that such places shall be filled with rubble laid in cement, ıortar, or with fine concrete packed solidly around larger stones, ac-ording to convenience. No motion can be permitted among the stones hich are to transmit the ultimate pressure to the rock in place, and ıis can only be certainly accomplished by filling up all interstices with solid mass.

Where the rock is still worse, so that timbering becomes necessary to ıe safety of the miners, the present plan is to insert such beams as may e needed and leave them in position. The Board advises the removal f all wood when practicable; and when not, to bed it in a solid mass of oncrete or rubble, filling all voids.

Finally, the case of overhead falls of rock producing extensive dome-ke cavities is presented. Fortunately these are not common, only two f very large size being reported by the engineer in charge. The Board isited the site of the worst one. It extended 31 feet along the axis of he tunnel and the fall had crushed the timbering and temporarily im-ırisoned the men at work. To obtain security the overhead cavity had ıeen at once filled with about forty cords of wood laid up as well as pos-

sible from the bottom, and the tunnel had been lined for a length feet with brick increased overhead at the most exposed portions inches in thickness (4 bricks). The space between the brick arch the wood overhead and between the arch and the rock in place sides had been filled in with dry stone packed as closely as possi

While it is probable that wood in such positions will be covered mately by water, this will not be true until the tunnel is filled; the mean time dry rot may be at work among this wood, as was be the case with the beams in several localities. But even if this so, the wood from its elasticity, especially when laid up under such advantages, can not be trusted to transmit the pressure tending to ure the brick arch when the tunnel is filled. The Board therefore siders that before the work is completed all wooden backing should replaced by solid masonry by means of auxiliary drifts run over the nel and filled solid with masonry, or by a new tunnel around the of the cave, filling up the present tunnel with masonry, or by a sunk at the locality, as may prove to be most economical.

In these recommendations the Board has considered that the cou pressure due to ground water or to water filtering through the of the tunnel, is too uncertain and too liable to variation at diff localities to be counted upon to give a sufficient support to the lining. In a case like the present, where a serious injury would consequences so disastrous, the brick work should be backed so as to serve merely as a vehicle for transmitting the pressure to the in place. In the valleys of Rock Creek and Foundry Creek, which points where the ground is 135 and 50 feet respectively below the surface in the reservoirs, and where the unbalanced pressures probably reach 58 and 21 pounds per square inch, all the lining backing wherever the rock is not unchanging and impermeable sh be done with the greatest care in the most substantial way and mortar rich in cement.

This rule should also apply for considerable distances from t valleys, since rock seams leading from the tunnel into these or depressions might much reduce the head of ground water, which w otherwise exist there, to balance the internal pressure upon the li of the tunnel.

The inspection of the new reservoir satisfied the Board that the is proceeding in an entirely satisfactory manner as proposed by special Board of 1885, and this Board has no changes to recommen

The total length of the tunnel when completed will be 20,700 and the engineer in charge states that the aggregate length then will in round numbers be about 12,000 feet, of which about 2,475 will probably have been timbered. At the present time, 1,740 have been lined and 1,175 feet timbered, these lengths being incl in the above figures.

Respectfully submitted,

J. C. DUANE,
Col. of Eng. and Brt. Brig. Gen., U. S.
HENRY L. ABBOT,
Lieut. Col. Eng. and Brt. Brig. Ge
C. B. COMSTOCK,
Lieut. Col. of Eng. and Brt. Brig. Ge
WALTER MCFARLAND,
Lieut. Col. of Engineer

Brig. Gen. JOHN NEWTON,
Chief of Engineers, U. S. A.

LETTER OF MAJOR G. J. LYDECKER, CORPS OF ENGINEERS.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., September 7, 1886.

IR: By order of the Acting Secretary of War, I have been furnished for my guid-e with the inclosed copy of the report of the Board of Engineers for fortifications l for river and harbor improvements in relation to the methods (1) of lining the nel and (2) of constructing the new reservoir, for increasing the water supply of ashington, D. C., made in pursuance of the deficiency act approved August 4, 1886.

As to the reservoir, the Board reports that "the work is proceeding in an entirely isfactory manner," and no changes are recommended.

As to the tunnel lining, the Board holds that the exclusive use of concrete is im-acticable, indorses the use of the brick arch as now constructed, but recommends at the filling between the arch and the rock in place be done "with rubble laid in ment mortar, or with fine concrete packed solidly around larger stones, according convenience" instead of with dry stone as heretofore. The recommendation of the ard, as I understand the act of Congress, is conclusive as to the method of lining be followed; so that the great question now to be determined is whether this work all be done "under the contract heretofore made or by a reletting."

If the present contract included prices for the "rubble masonry" and "fine con-ete" recommended by the Board, I should have no hestitation in recommending at the work be continued under this contract; but such is not the case, and if the ork is done by the present contractors, without a reletting, it will be necessary to ree upon a price for this large amount of work, aggregating at least 25,000 cubic yards masonry, exclusive of the brickwork. But the contractors claim that they have a ntract to complete this tunnel, and that the specifications and articles of agreement ake provisions for dealing with any change of plan that might be determined upon uring the progress of the work. If it is held that the contract, when made, was for ny more work than could be done with the money at that time appropriated by Con-ress, the contractors may be correct in their claim; but that is a legal question which is useless for me to discuss further, and I introduce it only to suggest that the con-ractors are probably prepared to interpose every legal obstacle in the way of putting ther parties on the work, whereby delay, damage, and increased expense would re-ult. The specifications describe the work to be done as "the construction of 20,826 eet, more or less, of tunnel about 11 feet wide and 7½ feet high from the present listributing reservoir above Georgetown to the proposed new reservoir east of Howard Jniversity." They further provide for masonry lining "wherever required," and eserve to the engineer in charge the right "to modify them (the specifications) whenever, in his opinion, it may be necessary for the proper accomplishment of the object in view."

Referring to the articles of agreement, they provide as follows:

"If, at any time during the prosecution of the work, it be found advantageous or necessary to make any change or modification in the project, and this change or mod-ification should involve such change in the specifications as to character and quan-tity, whether of labor or material, as would either increase or diminish the cost of the work, then such change or modification must be agreed upon in writing by the contracting parties, the agreement setting forth fully the reasons for such change and giving clearly the quantities and prices of both material and labor thus substi-tuted for those named in the original contract, and before taking effect must be ap-proved by the Secretary of War: *Provided*, That no payments shall be made unless such supplemental or modified agreement was signed and approved before the obli-gation arising from such modification was incurred."

The foregoing presents all the salient features of the case, and, after the fullest con-sideration, I have reached the conclusion that it will be "most promotive of the in-terests of the Government" and of the work to do the work of lining under the contract heretofore made with Beckwith & Quackenbush, if satisfactory prices there-for can be agreed upon. It has already been determined to continue and complete the work of excavation under this contract, and that work is in full blast; there is a large amount of rock trimming that will have to be done before the lining is placed in that part of the tunnel already excavated through by these contractors, which they would have to do without additional compensation; they have their tracks, hoisting machinery, pumping machinery, and all other necessary appliances in place and are therefore ready to proceed with the work at once; they have considerable material for lining on hand, delivered last year, before the work of lining was sus-pended in order that the small balance of funds then available might be applied solely to the work of excavation; they have proven themselves to be reliable and energetic in their work; they claim it as a legal right to complete it, and would un-doubtedly seek to maintain that right. In fact, the necessity of fixing a price, with-out competition, for the large amount of masonry of the kind recommended by the Board is the only material objection that occurs to me against the adoption of the

course indicated above; nevertheless this is exactly the line of procedure that appears to be contemplated in the articles of agreement to meet the requirements of a change of project, such as is now in question. If that course be approved I would suggest, and request, that a board of engineers of not less than three members be designated to consider and report upon the question of price.

Copies of the advertisement, specifications, and articles of agreement (blank) comprised in the contract, are transmitted herewith for ready reference.

Very respectfully,

G. J. LYDECKER,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
September 16, 1886.

Respectfully returned to Major Lydecker for an estimate of the amount and cost of the work proposed, and for a statement of the price at which the contractors will do the work, and for Major Lydecker's recommendation in connection therewith.

By command of Colonel Parke, in charge of office.

H. M. ADAMS,
Captain of Engineers.

[Second indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, October 1, 1886.

Respectfully returned to the Chief of Engineers, U. S. Army.

The exact amount of work to be done in lining the tunnel can not yet be stated, but from present indications it is estimated in round numbers that 12,500 cubic yards brick masonry, 4,500 cubic yards concrete, and 23,000 cubic yards rubble masonry will be required, the last item being in lieu of the dry stone packing contemplated in the original method of construction. The cost at prices named in the letter transmitted herewith, as those at which the present contractors will do the work, would be as follows:

12,500 cubic yards brick masony, at $14	$175,000
4,500 cubic yards concrete masonry, at $5	22,500
23,000 cubic yards rubble masonry, at $4.75	109,250
Total	306,750

These prices make an average of about $7.67 per cubic yard for the total 40,000 cubic yards of composite masonry in the tunnel lining. I do not believe that a reletting would result in anything less, and accordingly, as instructed in the foregoing indorsement, I recommend that supplemental articles of agreement for doing the work of lining in the modified manner as required by the report of the Board of Engineers, be entered into with the contractors now on the work, based on prices not to exceed those named above.

G. J. LYDECKER,
Major of Engineers.

[Third indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
October 5, 1886.

Respectfully returned to Major Lydecker, to state how much money will be available for the work proposed under supplemental contract.

By direction of Colonel Parke, in charge of office.

H. M. ADAMS,
Captain of Engineers.

[Fourth indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, October 9, 1886.

Respectfully returned to the Chief of Engineers, U. S. Army.

As nearly as I can estimate at this time it is probable that we will have about $86,000 available for the work proposed under the supplemental contract, *i. e.*, for rubble masonry in tunnel lining.

G. J. LYDECKER,
Major of Engineers.

(Four inclosures herewith, including originals.)

[Fifth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
October 14, 1886.

Respectfully returned to Major Lydecker, with directions to prepare a supplemental contract, to be submitted to the Secretary of War.

Expenditure under this supplemental contract to be limited to the amount available for the purpose specified, after deducting such amounts as will be required for engineering expenses.

By command of Brigadier-General Duane.

H. M. ADAMS,
Captain of Engineers.

[Sixth indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, October 18, 1886.

Respectfully returned to the Chief of Engineers, U. S. Army, with proposed supplemental contract, in quintuplicate, for consideration of the Secretary of War.

The extension of the original contract with Beckwith & Quackenbush to June 30, 1887, heretofore made with the approval of the Secretary of War, applied only to the "work of excavation and the removal of excavated material from the tunnel." If my present recommendation is approved, that extension should now be made to apply to the work of tunnel lining also, as it is proposed to do the brick and concrete part of this work under that contract at the prices bid at the original letting.

G. J. LYDECKER,
Major of Engineers.

COMMUNICATION ACCOMPANYING THE SECOND INDORSEMENT ON THE FOREGOING LETTER.

GEORGETOWN, D. C., *September* 29, 1886.

DEAR SIR: In reply to your communication of the 21st instant, while we do not admit the power to abrogate without cause our contract, or any part of it, and respectfully reserve all our legal rights thereunder, still, subject to this reservation, we are willing to agree to a modification of the contract, so that instead of "dry stone packing" there shall be substituted either or both of the methods mentioned in your letter.

We therefore name the following prices as requested in your letter, viz:

Eleven thousand five hundred cubic yards brick masonry, 4,500 cubic yards concrete masonry, the price provided by the existing contract.

Twenty thousand cubic yards rubble masonry laid in cement mortar for the price of $4.75 per cubic yard.

Twenty thousand cubic yards of fine concrete packed solidly around larger stone for the price of $6.50 per cucic yard.

Very respectfully,

BECKWITH & QUACKENBUSH,
Contractors.

G. J. LYDECKER,
Major of Engineers, U. S. A.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 27, 1886.

SIR: Your letter of September 7, inclosing the supplemental contract with Beckwith & Quackenbush, transmitted with your indorsement of 18th instant, was submitted to the Secretary of War, indorsed as follows:

[Seventh indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
October 19, 1886.

Respectfully submitted to the Secretary of War, with recommendations that the supplemental articles of agreement herewith be approved, and that the original contract herewith be extended, to include the tunnel lining, to June 30, 1887, as proposed by Major Lydecker.

J. C. DUANE,
Brig. Gen., Chief of Engineers.

And was received back with the following indorsement:

[Eighth indorsement.]

WAR DEPARTMENT,
October 26, 1886.

The recommendations of the Chief of Engineers are approved.
By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

Three copies of the supplemental contract are herewith returned to be disposed of in accordance with law and regulations; one copy has been sent to the office of the Second Comptroller to be filed with the original contract, and one copy is filed in this office.

The report of the Board of Engineers, dated August 24, 1886, the blank specifications, etc., the blank articles of agreement, and the letter of Beckwith & Quackenbush, dated September 29, 1886, received here with your letter, are also inclosed.

By command of Brigadier-General Duane.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Colonel of Engineers,
Brt. Maj. Gen., U. S. A.

Maj. G. J. LYDECKER,
Corps of Engineers.

Supplemental articles of agreement entered into this 18th day of October, 1886, between Maj. G. J. Lydecker, Corps of Engineers, U. S. Army, of the first part, and Clinton Beckwith and John V. Quackenbush, partners, doing business under the firm name of Beckwith & Quackenbush, of Mohawk, of the county of Herkimer, State of New York, of the second part.

Whereas on the 29th day of October, 1883, the parties above mentioned entered into a contract for the construction of a tunnel for increasing the water supply of Washington, D. C., which provided, among other things, for placing dry stone packing in connection with the lining of said tunnel at a stipulated price per cubic yard; and

Whereas the Congress of the United States, in appropriating for the completion of the work, in the general deficiency act approved August 4, 1886, instructed the Secretary of War "to submit to the Board of Engineers for Fortifications and for River and Harbor Improvements whether any changes are demanded for reasons of safety or economy in the method of lining said tunnel heretofore adopted and pursued"; and

Whereas the Board of Engineers aforesaid, in its report dated August 24, 1886, requires the use of "rubble laid in cement mortar or (with) fine concrete packed solidly around larger stone" in lieu of the dry stone packing hereinbefore referred to, thereby making necessary a modification in the original project such as involves a change by which the cost of the work will be increased: Therefore, in order to provide for the modification aforesaid in accordance with the provisions of the original contract dated October 29, 1883,

This agreement witnesseth, that the said Maj. G. J. Lydecker, Corps of Engineers, for and in behalf of the United States of America, and the said Beckwith and Quackenbush, for themselves, their heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other as follows:

That the said party of the second part, in consideration of the extension of the original contract to include the work of lining that may be done under the appropriation made by the act approved August 4, 1886, hereinbefore referred to, and of payment to be made as hereinafter provided, shall furnish all material for, and place rubble laid in cement mortar wherever required in the tunnel, all as directed by and to the entire satisfaction of the party of the first part.

In consideration of the material being furnished and the rubble laid as provided for in the foregoing paragraph, the said party of the first part shall pay to the said party of the second part at the rate of $4.75 per cubic yard; all payments being subject to the conditions named in the original contract.

It is expressly understood and agreed that all provisions of the contract entered into on the 29th day of October, 1883, between the parties herein named shall apply to the work and material provided for by these supplemental articles of agreement in so far as the said provisions are deemed applicable by the party of the first part; and that neither these supplemental articles of agreement nor any extension of the original contract whereby it is made applicable to the work on the tunnel provided for by the general deficiency act approved August 4, 1886, shall obligate the United States to any expenditure in excess of the amount thereby appropriated, after deducting there-

m the sums necessary for meeting outstanding liabilities for work done up to the e at which that appropriation became available, and for defraying the necessary penses of engineering, superintendence, and contingencies during the progress of work.

t is further understood that this agreement is to become operative only when apoved by the Chief of Engineers and the Secretary of War, and if not so approved it o be void and of no effect whatever.

n witness whereof the undersigned have hereunto placed their hands and seals the te first thereinbefore written.

Witnesses:
SIMON NEWTON.
JOHN M. LASKEY.

G. J. LYDECKER, [SEAL.]
Major of Engineers, U. S. A.
BECKWITH & QUACKENBUSH. [SEAL].

(Executed in quintuplicate.)
Approved, October 19, 1886.

J. C. DUANE,
Brig. Gen., Chief of Engineers.

WAR DEPARTMENT, *October* 26, 1886.

Approved.

WM. C. ENDICOTT,
Secretary of War.

CORRESPONDENCE RELATING TO THE RESERVOIR.

WASHINGTON, D. C., *June* 28, 1886.

SIR: We most respectfully call your attention to the expiration of our contract with e Government for the construction of the new Washington reservoir on July 1, 1886, d ask that the same be extended for one year. Various exigencies have arisen to revent our completion of this work, and to the inclemency of the weather is mainly tributable our failure, the excessive rainfall interfering with our designs most seously, the basin being flooded some half dozen times this spring. Again, it would e impossible to complete the reservoir on account of material for tunnel being in our ay. Regretting the circumstances which compel us to ask this extension, and trusting our petition may meet with your approval, we remain,

Very respectfully,

MALONEY & GLEASON.

Maj. G. J. LYDECKER,
Corps of Engineers, U. S. A.

[First indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, June 28, 1886.

Respectfully forwarded to the Chief of Engineers, U. S. Army. Under the original ontract this work was to have been completed by June 30, 1885. The time for comletion was extended one year, to June 30, 1886. The failure to complete on time (so ar as possible under the present appropriation) is, in my opinion, wholly due to a ack of vigor in the prosecution of the work, and in no sense to the violence of the lements or any exigency beyond the control of the contractors. For this reason I m not authorized by the terms of the contract to make the additional extension of ime herein requested.

The balance of funds available for "the construction of reservoir and *gate-house*" at he close of the month will be about $30,000. Of this amount $20,000 should be reserved for the gate-house, leaving only about $10,000 available for work on the reservoir nder the present appropriation. An estimate for an additional appropriation of $160,000 is now before Congress, and the proper steps to be taken for the completion of the work after the present appropriation is exhausted must depend to some extent on the action taken by that body. I would therefore recommend that the contract with Maloney & Gleason be extended to July 31, 1886 only, by which time the sum now available for work on the reservoir will probably be exhausted, and action by Congress in relation to the additional appropriation may have been taken.

G. J. LYDECKER,
Major of Engineers.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., July 7, 1886.

SIR: The letter of Maloney & Gleason, of 28th ultimo, requesting extension of time for one year from July 1, 1886, for completing their contract for construction of reservoir, forwarded to this office by your indorsement of same date, having been submitted to the Secretary of War, with recommendation that the contract be extended to July 31, 1886, as proposed by Major Lydecker, has been returned approved.

By command of the Acting Chief of Engineers.

Very respectfully, your obedient servant,

H. M. ADAMS,
Captain of Engineers.

Maj. G. L. LYDECKER,
Corps of Engineers.

LETTER OF MESSRS. MALONEY & GLEASON.

WASHINGTON, D. C., *July* 16, 1886.

SIR: Your esteemed favor of the 8th inst., extending our contract until July 31, 1886, duly received; and for reasons already referred to in our communication of June 28 last, would respectfully ask your still further extension to July 1, 1887.

Very respectfully, your obedient servants,

MALONEY & GLEASON.

Maj. G. J. LYDECKER,
Corps of Engineers, U. S. A.

LETTER OF MAJOR G. J. LYDECKER, CORPS OF ENGINEERS.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., August 16, 1886.

GENERAL: In further compliance with instructions contained in Department letter of the 9th instant, I have the honor to submit below a project for expending so much of the sum of $555,000 appropriated in the general deficiency act approved August 4, 1886, under the heading "Increase of the water supply of Washington, District of Columbia," relates to the reservoir. My project for the expenditure of that portion applicable to the tunnel was submitted in my letter of the 11th instant.

Of the sum above named $160,000 is appropriated "to complete the reservoir." This amount is named in my last annual report as that estimated as necessary for work that must be done before the water can be introduced and stored in the reservoir with due regard to security and purity, and for the auxiliary structures needed to take the water supply from the reservoir into the supply mains. This involves (*a*) the completion of the earth-work of the reservoir, and of paving and sodding the slopes, and the completion of the masonry conduits; (*b*) the construction of circulating conduits on the bottom of the reservoir, through which the water supply, as it emerges from the tunnel, will be conveyed to the three corners of the reservoir most remote from the effluent gate-house; (*c*) the construction of the gate-house and connection with the new outlet main; (*d*) the construction of keeper's dwelling, fences, etc.

The work involved in the first item above (*a*) is provided for in the contract with Maloney & Gleason, dated October 30, 1883; this contract expired June 30, 1885, but the time of completion was extended to June 30, 1886, and again to July 31, 1886, and the contractors are still on the work, engaged with a small force in finishing such parts as are liable to damage by the weather if left in an incomplete shape. These contractors have given us, in the main, work of a satisfactory character, but they have been dilatory, and have at no time carried on the work with that degree of vigor and such extensive plant and working force as were called for by their contract; if the most vigorous prosecution of the work on the reservoir were now a question of vital importance I should not recommend any further extension of their contract. But their failure to make the requisite progress has not affected the interests of the Government adversely, further than by increasing the cost of inspection, and it is not at all likely that other parties could now be put on the work to finish it any sooner than the present contractors can, considering the delays incident to a reletting to

ier parties and their arranging for commencing operations; I am also of the opin- that a reletting would result in increased cost to the Government.

The work that can be done under the present contract is estimated as follows at ntract prices:

7,000 cubic yards excavation, at 30 cents	$32,100.00
,000 cubic yards puddling, at 40 cents	14,400.00
,000 square yards sodding, at 20 cents	4,000.00
cubic yards cut-stone masonry, at $15	112.50
6 cubic yards brick masonry, at $9	2,304.00
200 cubic yards concrete masonry, at $5.50	6,600.00
cubic yards rubble masonry, at $6	480.00
3 square yards trap-rock lining, at $1	753.00
000 cubic yards broken stone lining, at $2	12,000.00
,000 square yards paving, at 28 cents	9,800.00
linear feet coping, at $5	435.00
	82,984.50

In relation to these prices, I would observe that at the original letting fifteen bids ere received (see abstract of proposals printed in Report of Chief of Engineers for 84, pages 2308 and 2309); of these three were below the contract price for excava- on, one being 24 cents, one 28 cents, and another 29 cents, and the remaining eleven nging from 33 to 41 cents, the average of all bids being 34.4 cents; but there remains ly about 100,000 cubic yards of such work to be done, the larger part of it at the per end of the reservoir, calling for the longest haul and giving the least margin profit, so that any bid as low as the contract price can hardly be expected at this me. As to puddling, however, it is not unlikely that a lower price than 40 cents ight be obtained, as we originally had six ranging from 11 to 39 cents, two at 40, nd seven ranging from 66 cents to $2.50; the average price, exclusive of the phe- omenal one of $2.50, was about 52 cents. The average price for sodding was 31 cents, our of the bids being 20 cents, but none less than that. The contract price for pav- ng (28 cents) is exceptionally low, all others ranging from 50 cents to $2, and aver- ging 88.8 cents. The average price for broken-stone lining was $1.90¼, six of the ids ranging from $1 to $1.75, two at $2, and six ranging from $2.10 to $2.60.

The items above enumerated cover the bulk of the work to be done, aggregating n value $72,300, out of a total of $82,984.50, at contract prices. The contract price is n each of these items, except stone lining, below the average bid, and gives in the ag- gregate $31,928 less than the average of these bids would. It is in view of this fact that am led to the opinion that a reletting of the comparatively small proportions of the work that remain to be done would result in increased cost to the Government; and, further, there is considerable dead work to be done in trimming and dressing un- finished slopes, for which the present contractors will receive no additional compen- sation, but which would constitute an item of cost to the Government if other con- tractors should go on the work to finish it.

In view of the above considerations I am of the opinion that it will "be most pro- motive of the interests of the Government" to do that part of the work now in ques- tion—comprising, in general terms, the earthwork on the reservoir, paving and sodding slopes, and completion of masonry conduits—under the contract heretofore made with Maloney and Gleason. This work may be properly carried on pending action upon the report of the Board of Engineers on the questions to be submitted to its consideration, as required by the act of appropriation. To that end I recommend the extension of said contract to December 31, 1886. If their prosecution of the work up to that time should prove satisfactory a still further extension—say to June 30, 1887—might then be made; if, however, progress should *not* be satisfactory, it would probably be better at that time to put other parties on the work to complete it, ar- rangements to that end being made during the winter months, so that operations could be promptly commenced in the spring, thereby avoiding any loss of time in the favorable working period of the year.

The other portions of the work that will be required, such as the construction of the gate-house, circulating conduits, keeper's dwelling, fences, surface gutters, etc., should be deferred for the present, until the Board of Engineers has made its report, and until most of the work contemplated by the contract heretofore made has been accomplished. Their execution will not take much time.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Major of Engineers.

Brig. Gen. JOHN NEWTON,
Chief of Engineers, U. S. A.

[First indorsement].

OFFICE CHIEF OF ENGINEERS, UNITED STATES ARMY,
August 25, 1886.

Respectfully submitted to the Secretary of War.

The within project of Maj. G. J. Lydecker, Corps of Engineers, for the application of so much of the appropriation contained in the general deficiency act approved August 4, 1886, as relates to the reservoir, which may be summarized as follows:

Completion of the earth-work and of paving and sodding slopes and completion of masonry conduits appears to be in accordance with the provisions of the act, and is recommended for approval. The work now proposed may properly be carried on previous to the receipt of report of the Board of Engineers on the questions submitted to its consideration as required by the act approved August 4, 1886.

JOHN M. WILSON,
Acting Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT, *August* 28, 1886.

By order of the Acting Secretary of War.
Approved.

JAY STONE,
Acting Chief Clerk.

[Third indorsement].

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
September 3, 1886.

Respectfully returned to Major Lydecker, Corps of Engineers, inviting attention to the preceding indorsements, by which he will be guided. After such record as may be necessary has been made this paper will be returned to this office.

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
in Charge of Office.

LETTER OF MESSRS. MALONEY & GLEASON.

NEW RESERVOIR OFFICE,
Washington, D. C., December 16, 1886.

SIR: Noting the fact that our present contract expires December 31, 1886, we would respectfully ask that the same be extended to such a time as may in your judgment seem proper.

The very unseasonable weather, together with a short season, and numerous delays, causes us to make this request.

Very respectfully,

MALONEY & GLEASON.

Maj. G. J. LYDECKER,
Corps of Engineers, U. S. A.

[First indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, January 19, 1887.

Respectfully forwarded to the Chief of Engineers, U. S. A.

This application is for a further extension of the contract for constructing the new reservoir for the local water supply made in October, 1883, and calling for the completion of the work by June 30, 1885. The time was extended to June 30, 1886, and finally to December 31, 1886, pursuant to recommendations contained in my letter to the Chief of Engineers, dated August 16, 1886. I then stated that "the contractors had at no time carried on the work with that degree of vigor and such extensive plant and working force as were called for by their contract." There has been no improvement in these respects during the period covered by the last extension, but I recommend, nevertheless, that the contract be still further extended to June 30, 1887, because I do not think that new contractors can be put on the work in its present condition with any advantage to the Government.

G. J. LYDECKER,
Major of Engineers.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 22, 1887.

IR: Your recommendation of the 19th instant, that the time for the completion of the ıtract of Maloney & Gleason for construction of reservoir for increasing the water ›ply of Washington, D. C., be extended to June 30, 1887, is approved.

3y command of Brigadier-General Duane.

Very respectfully, your obedient servant,

H. M. ADAMS,
Captain of Engineers.

Maj. G. J. LYDECKER,
Corps of Engineers.

REPORT OF LIEUTENANT C. McD. TOWNSEND, CORPS OF ENGINEERS.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., August 4, 1887.

MAJOR: I have the honor to submit the following report of operations for increasg the water supply of the city of Washington during the fiscal year ending June 30, 87:

The plan adopted for increasing the water supply of the city of Washington consts—

(1) In raising the dam at Great Falls to an elevation of 148 feet above mean high de at the navy-yard, and extending it across Conn's Island and the Virginia chanel of the Potomac River.

(2) Connecting the distributing reservoir, with a new reservoir which is being conructed north of the city and east of Howard University, by a tunnel with a normal ross-section of 82.5 square feet reduced to 76.4 square feet where lined.

(3) Building this new reservoir, which is to have a capacity of about 300,000,000 allons.

(4) Connecting this reservoir to the existing system of pipe distribution in the city y large water mains.

DAM AT GREAT FALLS.

At the close of the last fiscal year the dam had been completed with the exception of about 192 linear feet of coping. This was laid during the months of July and August and the work finished August 21, 1886.

TUNNEL.

On account of a lack of funds work was suspended on the tunnel February 1, 1886, at which time the east and west shafts had been lined, 18,538.2 linear feet of the tunnel had been excavated, and 1,489.6 feet lined with brick masonry and dry-stone packing. Connections had been made between all the headings with the exception of those from Champlain avenue shaft east and the east shaft west.

The work of excavation was resumed August 30, 1886, and the tunnel "holed" July 1, 1887, the length of tunnel excavated during the year having been 2,154 linear feet. About 400 feet of the rock encountered is a compact hornblende schist, nearly amphibolite; the rest of the rock is a talcose schist, readily disintegrated by the action of water and will require lining. Timbering was required for a distance of 371 feet.

In the section of the deficiency bill approved August 4, 1885, appropriating $395,000 to complete the tunnel, the Secretary of War was directed to "submit to the Board for Fortifications and Harbor Improvements whether any changes are demanded for reasons of safety or economy in the method of lining said tunnel heretofore adopted and pursued," etc. The question having been submitted to the Board it indorsed the use of brick for the lining, but in place of the dry stone filled in between the brick and rock, recommended that "such places shall be filled with rubble laid in cement or with fine concrete packed solidly around larger stone which are to transmit the ultimate pressure to the rock in place," etc. In accordance with this recommendation the use of dry-stone packing for lining was discontinued, and under supplemental articles of agreement approved by the Secretary of War October 26, 1886, the work of lining the tunnel was resumed, rubble masonry being employed in the place of the dry-stone packing, at a cost of $4.75 per cubic yard; 6,110.5 linear feet of the tunnel had been lined at the close of the fiscal year.

The location of the lined sections is shown is the following table:

Shaft.	Heading.	Stations.	Linear feet lined.
East	West	318–748	430.0
		345–2756	1,811.0
Champlain avenue	West	74–1167	1,093.0
		1308–2062	754.0
Rock Creek	East	1850–3124.5	1,274.5
	West	2465–2573	112.0
Foundry Branch	West	1781–2208	427.0
West	East	0–209	209.0
Total			6,110.5

In lining timbered sections as much of the timber as practicable is removed before the rubble is placed. When the removal of the timber is too dangerous a careful examination is made, all unsound pieces are replaced, and all vacant places filled with rubble masonry and concrete. In the heavy ground in the west heading Champlain avenue shaft, the thickness of the arch has been increased from three to four bricks for a distance of 264 feet.

The following is a résumé of operations in each heading—extracts from the report of Mr. George H. Coryell, assistant engineer, who has been in immediate charge of the work:

EAST SHAFT—WEST HEADING.

September 3, 1886.—Resumed active operations in drilling and driving the tunnel heading.

	1885.	1886.	1887.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Progress	1,413	800	1,087	3,300
Average monthly progress	122.80	114.30	108.70	
Average daily progress	4.76	4.40	4.36	
Timbering	378	518	294	1,190
Brick lining, completed	290	481	1,470	2,241

NOTE.—For the fiscal year 1887, in addition to the above, 23 linear feet constructed to the height of springing line.

	Full timber section.	Top timber section.	Lining sections, not timbered.	Total.
Excavated for lining—	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1885	317		449	766
1886	372	74	40	486
1887	407	20	1,181	1,608
Total	1,096	94	1,670	2,860

The sections where dry-stone packing and rubble masonry were used are as follows, viz:

	Linear feet.
Dry stone packing:	
Station 318 to 748	430
Station 945 to 1025	80
Station 1145 to 1197	52
Station 1475 to 1912	437
Total	999
Rubble masonry:	
Station 1025 to 1145	120
Station 1197 to 1475	278
Station 1912 to 2756	844
Total	1,242

Also 2756 to 2779—23 linear feet constructed to height of springing line.

East heading, Champlain avenue shaft.

Heading turned May 21, 1884; heading completed June 30, 1887. Total distance, 348 feet.

	1884.	1885.	1886.	1887.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
ogress	113.00	1,487.00	694.00	1,054.00	3,348.0
verage monthly progress	82.50	124.00	99.10	105.40	....
verage daily progress	3.15	4.78	3.82	4.37	....

	Full timber section.	Top timber section.	Lining section not timbered.	Total.
xcavated for lining:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1887	77	....	594	671

Champlain avenue shaft—west drift.

The sections where dry-stone packing and rubble masonry were used are as follows, viz:

	Linear feet
Dry-stone packing:	
Stations 74 to 666	592
Stations 743 to 766	23
Stations 815 to 867	52
Total	667
Rubble masonry:	
Stations 666 to 743	77
Stations 766 to 815	49
Stations 867 to 2062	1,195
Total	1,321

The following will show sections where brickwork of four rings have been used, viz:

	Linear feet.
Stations 815 to 846	31
Stations 867 to 1050	183
Stations 1390 to 1440	50
Total	264

NOTE.—The invert in the above sections were not added to, except between stations 815 and 846 an additional ring of brickwork added, making it three rings thick,

Heading turned May 21, 1884. Heading completed Nov. 9, 1885. Total distance, 2,062 feet.

	1884.	1885.	1886.	1887.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Progress	91.00	1,404.00	567.00	....	2,062.00
Average monthly progress	66.40	117.00	135.00	....	....
Average daily progress	2.35	4.50	5.28	....	....
Timbering	....	2.79	......	.81	3.60
Brick-lining	....	403.00	264.00	1,180.00	1,847.00

NOTE.—For the fiscal year 1887, in addition to the above, 141 linear feet constructed to the height of springing line.

	Full timber section.	Top timber section.	Lining section, not timbered.	Total.
Excavated for lining:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1885	179	100	858	1,137
1886	....	....	334	....
1887	81	....	460	541
Résumé	334	26	1,652	2,012

East heading, Rock Creek shaft.

Heading turned January 27, 1884; heading completed November 14, 1885. Total distance, 3,124½ feet.

	1884.	1885.	1886.	1887.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Progress	372.00	1,857.00	895.50	....	3,124.50
Average monthly progress	72.80	154.75	200.30	....	....
Average daily progress	2.60	5.95	7.48	....	....
Brick lining	....	....	....	1,274.50	....
Timbering (length timbered)	....	.11	....	....	....

NOTE.—Length timbered temporary. No allowance made in estimates not excavated to timber section.

Excavated for lining:

1884. Length.	
1885. Length lining section	50
1886. Length	
1887. Length lining section	1,349
Total	1,399

NOTE.—About 650 linear feet excavated for lining in 1886 allowed in 1887.

West heading Rock Creek shaft.

Heading turned January 27, 1884; heading completed January 5, 1886; total distance, 3,552 feet.

	1844.	1885.	1886.	1887.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	
Progress	467	2,062	1,023	....	3,552
Average monthly progress	91.60	171.80	165	....	....
Average daily progress	3.30	6.64	6.10	....	....
Brick lining	....	....	....	112	....

NOTE.—In addition to above 63 linear feet constructed to the height of springing line.

Timbering:

1884. Length	
1885. Length	40
1886. Length	
1887. Length	

NOTE.—Seven linear feet of above temporary, and not allowed in the estimates, not excavated to timber section.

Excavated for lining:

1884. Length	
1885. Length	80
1886. Length	
1887. Length	1,262
Total	1,342

NOTE.—350 linear feet excavated in 1886; allowed in 1887.

Foundry Branch shaft; east heading.

Heading turned February 12, 1884; heading completed January 8, 1886; total distance, 2,875.7 feet.

	1884.	1885.	1886.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Progress	313.00	1,652.00	910.70	2,875.70
Average monthly progress	67.45	137.66	146.40	....
Average daily progress	2.53	5.30	5.71	....

Timbering, none; brick lining, none.
Excavated for lining, 1887, length (lining section), 153.

NOTE.—The above was enlarged for lining in 1886; allowed in 1887.

West heading, Foundry Branch shaft.

Heading turned February 13, 1884; heading completed July 31, 1885; total distance, 2,208 feet.

	1884.	1885.	1886.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Progress	280.00	1,778.00	150.00	2,208.00
Average monthly progress	62.78	148.16	150.00	....
Average daily progress	2.32	5.71	5.55	....

Timbering, none.
Brick lining:
For the fiscal year 1887 ....feet.. 427.00
Excavated for lining:
For the fiscal year 1887 ....feet.. 968.00

West connecting shaft, east drift.

Heading turned June 17, 1884; heading completed December 15, 1884; total distance, 209 feet.

	1884.	1885.	1886.	1887.	Total.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Progress	13.00	196.00	....	....	209.00
Average monthly progress	27.00	31.00	....	....	....
Average daily progress	1.08	1.18	....	....	....
Timbering (length)	....	46.00	....	....	....
Brick lining (length)	....	52.00	....	157.00	209.00

The balance available for continuing the work is $123,837.70. At the present rate of progress this amount will be expended on or before the 1st of November.

The contractors, Messrs. Beckwith and Quackenbush, have exhibited zeal and intelligence in the prosecution of the work. A higher rate of progress could have been attained in lining the tunnel, had it not been evident that the work must be suspended for lack of funds. The estimate submitted in 1885 was based upon the assumption that dry-stone packing was to be employed in lining. The substitution of rubble masonry has largely increased the cost. At the time that estimate was computed but 13,500 feet of the tunnel had been excavated, and the character of the remaining rock was entirely a matter of conjecture. The bore of the tunnel has now been completed, and the character of the rock can therefore be accurately determined. A careful investigation has been made and it is found that much more of the rock than was then assumed will require lining. In addition to the 6,110.5 feet which has already been completed there, there are 1,915 feet of the tunnel which will require through-

out, being in a rock liable to disintegrate from the action of water. The causes of [illegible] integration are generally impure talc and an excess of mica and iron pyrites. [illegible] 4,100 feet is through rock, which, though not liable to disintegrate, contains [illegible] and seams which cause it to break irregularly, and both the roof and sides will re[illegible] lining. As the bottom of the tunnel forms a firm foundation no invert will be req[illegible] in these sections. For a distance of about 3,000 feet the side-walls are firm and [illegible] pact, but the roof will require support. The remaining 5,761 feet appear to be [illegible] and compact rock, not liable to disintegration. The question whether these sec[illegible] should be left without any support is worthy of careful consideration. When the [illegible] nel is filled with water its walls will be exposed to a pressure of over 50 pound[illegible] square inch. What the effect of this pressure on the bare rock will be is diffi[illegible] determine. The conduit is of a novel character, and from preceding experienc[illegible] little information can be derived. Under the pressure of the water may not the[illegible] break in such a manner as to endanger the stability of the roof, *i. e.*, pieces which [illegible] form a key fall out and the tunnel fill with the débris? It is known that in rock [illegible] seemed compact when originally excavated cracks have afterwards appeared. [illegible] the tunnel is filled, and water introduced into the city, any repairs will be a sou[illegible] great delay and expense. Without the tunnel be tested by being once filled [illegible] water and afterwards examined, I do not consider that it would be safe to leave [illegible] portion of the roof unsupported. The sides through these sections can then be left [illegible] rock without serious danger. When the tunnel is filled, if the rock breaks up it [illegible] remain in place unless the lower plane of cleavage makes an acute angle with the [illegible] of the tunnel. While this may take place to some extent, it is not considered pos[illegible] for it to be sufficient to endanger the stability of the arch.

The various forms of lining recommended are shown on the accompanying trac[illegible]

The estimate of the cost of the work is as follows:

Tunnel excavation	$650,9[illegible]
Tunnel lining	391,6[illegible]
Air shafts, estimate of 1885	6,[illegible]
Working shafts, estimate of 1885	63,[illegible]
West connection, estimate of 1885	9,[illegible]
Extra pumping during suspension of operations, 1886	7,[illegible]
Engineering, superintendence, and contingencies	50,[illegible]
Total	1,181,[illegible]
Appropriated	999,[illegible]
Balance required	182,[illegible]
To arch 5,761 feet	117,[illegible]
Total	299,7[illegible]

The following is a detailed estimate of the cost of excavation and lining:

Sections lined with arch, side-walls and invert.

EXCAVATION.

1,609 feet timbered section (167.3 square feet), 9,970 cubic yards, at $8	$79,76[illegible]
120 feet timbered section (143.4 square feet), 637 cubic yards, at $8	5,09[illegible]
6,296 feet lining section (109.67 square feet), 25,573 cubic yards, at $8	204,58[illegible]

LINING.

Brick, 8,025 feet (32.3), 9,898 cubic yards, at $14	138,57[illegible]
Dry stone packing, 1,489.6 feet, 4,936.72 cubic yards, at $2.50	12,34[illegible]
Rubble masonry, 6,536 feet (66.15), 16,013 cubic yards, at $4.75	76,06[illegible]
Concrete, 8,025 feet (8.64), 2,568 cubic yards, at $5	12,84[illegible]
	529,25[illegible]

SECTIONS LINED WITH ARCH AND SIDE-WALLS.

4,100 feet excavation (105.38), 1,600 cubic yards, at $8	$128,016[illegible]
4,100 feet brick (27.6), 4,191 cubic yards, at $14	58,674[illegible]
4,100 feet rubble (66.15), 10,045 cubic yards, at $4.75	47,713[illegible]
4,100 feet concrete (2.00), 304 cubic yards, at $5	1,520[illegible]
	235,923[illegible]

SECTION LINED WITH SEGMENTAL ARCH.

3,000 feet excavation (101.79), 11,310 cubic yards, at $8	$90,480.00
3,000 feet brick (16.8), 1,867 cubic yards, at $14	26,138.00
3,000 feet of rubble (32.0), 3,555 cubic yards, at $4.75	16,886.25
3,000 feet concrete (2.0), 222 cubic yards, at $5	1,110.00
	134,614.25

NORMAL SECTION.

5,761 feet excavation (82.5), 17,603 cubic yards, at $8	140,824.00
Excess dimensions, 1,000 cubic yards, at $1.50	1,500.00
	142,324.00

IF LINED WITH SEGMENTAL ARCH.

5,761 feet excavation (19.29), 4,116 cubic yards, at $8	32,928.00
5,761 feet brick (16.8), 3,585 cubic yards, at $14	50,190.00
5,761 feet rubble (32.5), 6,828 cubic yards, at $4.75	32,433.00
8,761 feet concrete (2.0), 427 cubic yards, at $5	2,135.00
Total	117,686.00

THE NEW RESERVOIR.

At the close of the last fiscal year there had been excavated 727,000 cubic yards of material; the dam had been raised to a mean elevation of 153.7 feet. The east conduit had been completed, and 1,594 feet of the west conduit. The inside slope of the dam, the east slope, and 255 feet of the west slope of the reservoir had been paved.

The progress of the work during the present year has been unsatisfactory. The work of excavation was practically suspended during the months of July and August, awaiting an appropriation by Congress, and during September pending decision upon the application of the contractors for an extension of their contract. Moderate progress was made during the months of October and November, but since that date little has been accomplished. The plant employed has been in poor condition, and the force entirely inadequate. The following table shows the number of days' labor during each month:

Days service.

Month.	Laborers.	Masons.	Pavers.	Animals.	Steam excavator.	Locomotives.
1886.						
July	1,763	24	117	253	23	48
August	1,175	20	107	150	25	50
September	1,420		80	138	20	33
October	2,800	1	231	375	25	50
November	2,329	34	270	329	23	46
December	515		110	60	20	36
1887.						
January	135				9	18
February						
March			153			
April	1,554	11	286	100		42
May	2,187	25	288	250	5	50
June	1,242		189	244	21	50
Total	15,120	115	1,831	1,899	171	423

One hundred and one thousand one hundred and eighty-six cubic yards have been excavated during the year; the dam has been brought to full height and width with the exception of about 350 feet at the west end, which is about 2½ feet below grade. The levees at the north and east sides of the reservoir have been brought to subgrade, and the low ground south of the dam filled in readiness for sodding. The west conduit has been completed; 1,994 linear feet of the west and northern slopes of the reservoir, and 942 feet of road gutters have been paved. Six hundred and eighty and seventy-five hundredths cubic yards of stone have been hauled from Rock Creek and Foundry Branch and Champlain avenue shafts for paving.

The work remaining to complete the contract is to excavate and pave a portion of the north hill and the recess for the gate-house; about 25,000 yards excavation and 9,500 square yards paving, to trim and sod the dam, to bring the roadway to grade, and clean and level the bottom of the reservoir. The amount available to complete the work is $116,967.66.

MAIN CONNECTIONS..

The only work on the main connections during the year was the calking of the 75-inch outlet main from the new reservoir; this work was commenced January 19, and completed February 28, 1887.

The balance available is $2,008.58, which will probably suffice to complete the work.

Very respectfully, your obedient servant,

C. McD. TOWNSEND,
First Lieutenant of Engineers.

Maj. G. J. LYDECKER,
Corps of Engineers, U. S. A.

VV 3.

ERECTION OF FISH-WAYS AT GREAT FALLS OF THE POTOMAC.

As fully explained in my last annual report, all operations on the fish-ways at the Great Falls had been supended after their damage by the floods of October, 1885, and final settlement made with the contractor in February, 1886.

No work was in progress at the beginning of the fiscal year, and whatever remained of the fish-ways was still under water, the precise extent of damage done to them still unknown, and the feasibility of completing them undetermined. In the meantime, however, the United States Commissioner of Fisheries, in whose office the plans and specifications for the work had been prepared, had requested that steps be taken to complete the sixth section, of which action I was advised by the Chief of Engineers under date of June 16, 1886. Prior to that, under date of June 14, 1886, I had applied to the Chief of Engineers for a remittance of funds to enable me to reconstruct the dam which intercepted the flow of water through the channel in which the fish-ways were located, with a view to ascertaining their exact condition, and what, if anything, could be done towards their restoration. The questions of so doing and of completing the sixth section as requested by the Commissioner of Fisheries were before the Department for consideration at the beginning of the fiscal year, and under date of July 13, 1886, I was authorized to proceed with the work (see copy of correspondence herewith).

Operations in pursuance of the above authority were commenced on the 7th of August, it having not been deemed advisable to start work before that date on account of continuing high water. The reconstruction of the dam was completed early in September, and the flow of water thereby diverted from the site of the fish-ways in the Falls branch of the Potomac. It was then found that little more than the sixth section remained, and that was found filled up with sand, gravel, and stones, the removal of which required the tearing away of a considerable portion of the superstructure. The work of repairing this section was then commenced and continued until the early part of November, when the work was completed, at a total cost of $3,741.49.

This section has remained without injury since that date, and its practical working as a fish-way been the subject of observation on the

t of the officers of the Fish Commission. I am advised that the ult of these observations is, in the main, satisfactory, and that the npletion of the fish-ways on the general principles involved in the nstruction of this section is desired by the Commissioner of Fisheries. do this in such substantial manner as to withstand the violent floods the Potomac in this locality will probably cost upwards of $50,000, pending largely on the details of the plan that may finally be adopted. wever, I do not understand that this Department is called upon to omit any estimate for this purpose, nor does it appear, in fact, that ere has been any specific legislation devolving the construction of ese fish-ways upon the War Department, though the intent of Conss has been so construed. The appropriation for the work was origilly made in the act entitled "An act to increase the water supply of city of Washington, and for other purposes," approved July 15, 32, and simply provided "for the erection of suitable fish-ways at the eat Falls of the Potomac and at the dam to be constructed under the ovisions of this act in accordance with plans and specifications to be escribed by the United States Commissioner of Fish and Fisheries." is act specifically authorizes and directs the Secretary of War to do rtain work pertaining to the increased water supply, but is silent as any duty or responsibility on his part in relation to the fish-ways. would therefore seem desirable that, if further appropriation be made r these structures at the Falls, Congress should more definitely assign e duty and responsibility of its disbursement.

The original appropriation was $50,000, of which there had been exnded to June 30, 1887, $44,365.18, leaving $5,634.82 as the balance en available.

The following is a money statement for the fiscal year ending June , 1887:

mount available July 1, 1886	$9,376.31
mount expended during the year	3,741.49
Balance available June 30, 1887	5,634.82

CORRESPONDENCE RELATING TO THE FISH-WAYS AT GREAT FALLS.

UNITED STATES COMMISSION OF FISH AND FISHERIES,
Washington, D. C., May 12, 1886.

DEAR SIR: In obedience to your instructions I proceeded to the Great Falls of the otomac May 3 to make the necessary arrangements for observing the working conitions and efficiency of the sixth or lowest section of the series of fish-ways now uner construction there.

The construction of the fish-ways was carried on under a contract the conditions f which required that the entire work should be completed on the 31st of October, 885. The high water occurring about that date found none of the six sections contituting the series of fish-ways completed. Five sections were under construction nd in a condition to be damaged by the high water. The lowest or sixth section ras most advanced towards completion, needing only the setting of the line of coping provided for in the plans and specifications to insure the permanence and duraility of the construction.

A careful examination of No. 6 shows that it has suffered little or no injury from he floods and ice of the past winter, and that it is in perfect working condition, and ieeds only to be completed as planned to render this part of the construction perianent.

The work remaining to be done is as follows:

(1) The erection of a weir-dam about 40 feet long and 5 feet high from the abutnent of fish-way to the opposite shore, the object of this being to regulate and to conrol the supply of water to the fish-way, and at the same time to provide for the lischarge of the surplus water.

(2) To clear out the channel below the weir-dams so that the water flowing over the dam may be discharged into the river below, by the side of the fishway, instead of over the lower end as is now the case.

(3) Placing and securing of the 12-inch coping to cover the rubble-masonry walls forming the sides of the fish-way.

(4) The removal of the loose rock now piled up at the lower end of the fish-way and excluding fish from access to it.

This work may be undertaken at once, and if prosecuted actively may be finished in time to have a thorough test of the efficiency of the fish-way the present season.

The most expensive part of the work will be the coping. This, however, is necessary for the permanence of the fish-way and not for its proper working, and its setting may be deferred until low water during the summer.

The construction of the waste-weir and the removal of the rock from the overflow channel and at the foot of the fish-way are necessary to secure proper working.

There is, I am informed, still unexpended and available of the appropriation about $10,000.

And I respectfully recommend that the matter be brought to the attention of the honorable Secretary of War, with the request that he authorize or direct the completion of No. 6 in accordance with plans and specifications.

Very respectfully, your obedient servant,

MARSHALL MCDONALD.

Professor S. F. BAIRD,
U. S. Commissioner of Fisheries.

LETTER OF THE UNITED STATES COMMISSIONER OF FISHERIES.

UNITED STATES COMMISSION OF FISH AND FISHERIES,
Washington, D. C., June 9, 1886.

SIR: A year or two ago Congress made an appropriation of $50,000 for the placing of a fish-way at the Great Falls of the Potomac, for the purpose of allowing the upper passage of migratory fish in a locality owned by the United States, the selection of a plan to be made by the United States Fish Commissioner, and the work to be carried out by the United States engineers.

After carefully considering all the known methods, I finally selected a plan invented by Col. Marshall McDonald, an officer of the Fish Commission, and the estimate for its construction coming within the amount of the appropriation, I reported the fact to the War Department, which had the matter put in hand under the direction of the United States engineers.

Owing to very heavy rains supervening before the sections of the fish-ways could be properly strengthened a considerable amount of damage was done to the work, and operations have remained in abeyance for some time past. I directed Colonel McDonald to visit the locality and make a report upon the present condition of the work, which I forward herewith to you for your information.

If there is no good reason to the contrary, I would respectfully ask that the work be continued at least to the completion of the lowest section, as by this means we shall be able to determine whether it will actually answer its proposed purpose. I understand that there are sufficient funds in hand for doing this; and it is probable if more are required to complete the entire work they can be obtained from Congress.

Very respectfully, your obedient servant,

SPENCER F. BAIRD,
Commissioner.

Hon. W. C. ENDICOTT,
Secretary of War.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
June 16, 1886.

Respectfully referred to Maj. G. J. Lydecker, Corps of Engineers, for his information and early report. To be returned.

JOHN G. PARKE,
Acting Chief of Engineers.

[Second indorsement.]

OFFICE WASHINGTON AQUEDUCT,
Washington, June 19, 1886.

Respectfully returned to the Chief of Engineers, U. S. Army.

To complete the sixth section and do the other work suggested in the inclosed report by Mr. Marshall McDonald will be a simple matter as soon as the flow of water through the Falls Branch is interrupted, as proposed in my letter of the 14th instant. The unexpended balance of the appropriation for the fish-ways is $9,376.31.

This section is much less liable to damage from freshets, drifts, etc., than any of the others, and when completed will afford a good test of the practical working of the system. I most respectfully recommend that the work be commenced at once, as requested by the Commissioner of Fisheries. It is recommended, further, that the work be done by hired labor, as it will not be practicable to specify in advance what is necessary to be done.

G. J. LYDECKER,
Major of Engineers.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington D. C., July 13, 1886.

SIR: Referring to your report of the 19th ultimo upon the letter of Prof. S. F. Baird to the Secretary of War, of the 9th ultimo, inclosing report of Col. Marshall McDonald relative to the condition of the fish-ways, at the Great Falls, the Secretary of War has approved the following recommendation of the Chief of Engineers:

"That work upon the sixth section of the fish-way, together with the other work referred to, be commenced at the earliest practicable moment and prosecuted to completion in accordance with the provisions of section 3709, Revised Statutes."

You will be governed accordingly.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Acting Chief of Engineers.

Maj. G. J. LYDECKER,
Corps of Engineers.

APPENDIX W W.

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA.

REPORT OF COLONEL JOHN M. WILSON, UNITED STATES ARMY, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
Washington, D. C., July 5, 1887.

GENERAL: I have the honor to submit the following report of operations upon public buildings and grounds under the Chief of Engineers carried on under this office during the fiscal year ending June 30, 1887.

In addition to these duties I was in charge of the first and second divisions of the office of the Chief of Engineers until December 17, 1886; and since October 21, 1886, I have been in charge of the construction of the building for the Army Medical Museum and Library; the erection and unveiling of the pedestal and statue of the late President James A. Garfield; the erection of a monument at Washington's Headquarters, Newburgh, N. Y.; the erection of a monument to mark the birth-place of Washington, and the improvements over the grave of Thomas Jefferson at Monticello, Va.

GROUNDS SOUTH OF THE EXECUTIVE MANSION.

These grounds include those within the iron fence south of the White House, the road between the White House Grounds and the Treasury Department, and the entire reservation south of the White House, the Treasury, and the War, State, and Navy Building, and north of B street, between Fifteenth and Seventeenth streets.

During the year the main roads have been repaired, raked, and rolled compactly, using for this purpose about 500 cubic yards of gravel. These roads were well watered during the summer season in order to keep down the dust.

A new gravel walk was constructed in the western section of the reservation, running from the intersection of D and Seventeenth streets to the main road around the ellipse. This new walk covers an area of about 1,500 square feet. It was constructed in the most careful manner, requiring about 100 cubic yards of broken stone and 150 cubic yards of gravel. At its junction with the main road a rubble-stone gutter 50 feet long and 2 feet wide was constructed, and a brick

sewer-lodge built and connected with a 12 inch terra-cotta drain leading to the main sewer on Seventeenth street.

All roads, gutters, drain-traps, etc., south of the White House were kept clean and in good repair. All lawns, covering an area of about 40 acres, were mown several times and maintained in perfect order, except that of the ellipse, which, up to May 20, 1887, was also in excellent condition.

Extensive additions were made to the trees and shrubbery. Within the Executive Mansion Grounds handsome ornamental flower-beds were laid out and planted, and a few new trees, a number of rhododendrons and other handsome shrubs set out. In the western portion of the park south of the main road between Fifteenth and Seventeenth streets, 450 flowering shrubs and 180 deciduous and evergreen trees were planted.

The stone lodges at the southeast and southwest corners of the reservation were repaired. A new roof was added to the former and a new floor laid.

About 200 yards of soil and manure were used in planting.

All other trees and shrubs were pruned, mulched, and maintained in good order.

By authority of the Secretary of War, the ellipse, containing an area of 17 acres, south of the Executive Mansion, was transferred to the care of the National Drill Committee early in May for use as a drill ground for the troops congregating in this city during the latter part of May. The grounds were fenced in and a grand-stand erected. While the grass on the lawn of the ellipse was badly trampled down and worn out in many places, no damage was done other than this temporary injury to the lawn.

A bond in the sum of $2,500 was executed by the chairman of the drill committee whereby he was held individually liable for any damage that might be done to the grounds while in charge of the committee.

On June 1 the committee began the removal of all fences, etc., and by the close of the fiscal year they had cleared up the grounds and put everything in order as far as possible. It is anticipated that by early autumn the grass on the ellipse will be in as good condition as before the drill.

It was believed that the drill would be a national affair, would advance the interests of the militia throughout the country, and that the use of the grounds for this purpose was therefore eminently proper. It will be well, however, in my opinion, to select some other section of the city for a drill and camping ground in case it is proposed to repeat the affair; or in case it may be deemed best by the proper authorities to grant a similar privilege it should be coupled with the proviso that only the troops be allowed on the lawn of the ellipse, and that no structure of any kind be erected upon it.

None of the United States appropriation for care of these grounds has been used during the fiscal year for repairs incident to this drill.

During the coming fiscal year it will be necessary to make new sewage arrangements, on account of the filling of the Potomac Flats; and that portion of the reservation so long used for storage purposes during the construction of the War, State, and Navy Building, covering an area of about 2 acres, must be made to correspond with the remainder of the reservation.

MONUMENT GROUNDS, GREEN-HOUSES AND NURSERY.

The appropriation for the Monument Grounds was all expended previous to May 20, 1887, when the reservation was occupied as a camping

ground for the troops assembling from various sections of the country to take part in the National Drill.

During the year the lawns of that portion of the reservation not occupied by the Washington Monument Commission were mown three times and about four tons of hay secured and stacked at the nursery grounds for the maintenance of the public animals belonging to this office.

The main road between the monument and the nursery was repaired and improved from the new boiler-house to Fourteenth street, about 600 cubic yards of gravel having been used for this purpose; 243 linear feet of cobble-stone gutter, 2½ feet wide, was constructed on the sides of the roadway in the vicinity of the nursery. The lawns were edged on each side of the main roads and the gutters and drain traps cleaned from time to time; other portions of the roadways and gutters were repaired and patched where necessary.

By authority of the Secretary of War the Monument Grounds were transferred on May 15 to the national-drill committee for camping purposes; no damage was done to the reservation other than the temporary destruction of the grass in a few places, which was immaterial as far as a large portion of the grounds was concerned, as they are now being filled and regraded.

Early in June the tents and floors were removed and, at the close of the fiscal year, except as far as the temporary injury of the grass was concerned, the grounds were restored to their original condition.

No portion of the United States appropriation was expended for any repairs rendered necessary by the use of the grounds for camping purposes.

The work in connection with filling and grading the grounds around the monument renders it almost impossible to maintain the reservation in a sightly condition.

Extensive repairs were made during the year to the green-houses.

The entire superstructure of houses Nos. 1 and 2 was rebuilt, and an addition constructed west of No. 1, 100 feet long by 13 feet wide, into which 200 feet of 4-inch pipe for heating purposes was conducted.

Two brick cold frames, each 75 feet long by 6 feet wide, and 265 linear feet of wooden cold frames 6 feet wide, were built for planting bulbs, etc.

About 2,000 linear feet of shelving was put up, and 40 large plant tubs, 650 plant boxes, 23 seed boxes, 15 wooden trays, 200 by 6 feet of slat work for shading, and 57 straw mats for protecting cold frames were made.

A new tin roof, covering 936 square feet, was placed on potting-house No. 2, and the roof of potting-house No. 1 was thoroughly repaired, both roofs being painted; 800 square feet of new flooring was laid in these potting-houses, and a new bin to hold 80 tons of coal constructed in the cellar.

At the different houses there was made and put in place 600 feet of 7-inch tin gutter, and 300 feet of 8-inch copper gutter, with the necessary down spouts.

All furnaces and heating apparatus were cleaned and put in order, and numerous minor repairs of various kinds made to all the green-houses.

About 5,000 plants were placed under glass in the green-houses, consisting of carnations, begonias, heliotrope, bouvadias, sweet alyssum, and smilax, and about 800 roses; there were also boxed and potted for winter bloom 5,000 lilies of the valley, 3,700 hyacinths, 1,500 liliums,

1,000 narcissus, 1,000 tulips, and 1,000 freesia; in the cold frames, for spring bloom, 400 pansies and 1,800 liliums were set out.

During the winter months the propagation of bedding-plants for the parks was continued, and about 290,000 ornamental foliage and flowering plants, of about sixty varieties were grown, nearly all of which were set out in the parks during the months of May and June; among these were about 80,000 echeveria, now largely used in decorative bedding, also a number of chrysanthemums for late fall flowering.

A large number of palms, crotons, and sub-tropical plants were cared for in the green-houses during the winter and used in park decorations during the summer.

About 20,000 spring flowering bulbs were purchased and used in early spring decorations in the various parks.

At the nursery the young trees and shrubs were properly cared for, the roadways and gutters kept in order, and the grass mown from time to time; 3,196 plants and 1,800 young trees and shrubs were set out for stock and for summer bloom.

A new drain to carry off the water from the green-houses and closets was constructed; it consisted of 492 feet of 10-inch and 96 feet of 6 inch terra-cotta pipe placed in position in a trench 6 feet deep.

I am frequently in receipt of requests for the loan of plants from the gardens for the use of churches, fairs, festivals, etc., and demands are constantly made for decorative and other plants for private purposes.

I have been obliged to decline all such requests, as either the loan or gift of any plants would be in violation of the following extract from the act of Congress approved June 20, 1878.

Provided, That hereafter only such trees, shrubs, and plants shall be propagated at the green-houses and nursery as are suitable for planting in the public reservations, to which purpose only, the said productions of the green-houses and nursery shall be applied.

In the propagation of plants there are a few flowers blooming, and it has been a pleasure to this office to extend to Senators, Representatives, and other distinguished officials, and to churches, festivals, fairs, etc., the courtesy of sending to them these blooms, as far as the quantity on hand will admit. The requests for flowers are numerous and all letters received in reference thereto are filed, and a complete record kept of those to whom flowers are sent.

As the area of the improved reservations annually increases, it becomes necessary to increase the number of plants propagated, and this year it is larger than ever before, aggregating about 290,000.

SMITHSONIAN GROUNDS.

Extensive improvements have been made in these grounds during the year.

The main drive in front of the Museum Building has been covered with a first-class asphalt pavement from the Seventh-street entrance to a point about opposite the middle of the Museum building; the area improved was 2,767 square yards; about 2,500 additional square yards will be laid this season, thus extending the improvement to a point about opposite the western wing of the Smithsonian Building, it is regretted that the funds available are not sufficient to complete this pavement through to Twelfth street this year.

All the other roads leading from Seventh, Tenth, and Twelfth streets to the Museum and Smithsonian Buildings, covering an area of several

thousand square yards, have been repaired and rolled during the year; about 1,500 cubic yards of gravel have been used in these repairs.

The lawns have been mown several times, rolled and edged along the roads and paths and sodded where trespassers had damaged them; about 700 square yards of sod have been laid in various places; about 1,050 cubic yards of compost was spread over the lawns during the winter for fertilizing purposes and raked off at the opening of spring.

The four stone pillars on the line of the iron fence on the north boundary of the grounds were repaired and painted.

All gutters, drains, and sewer traps have been cleaned from time to time during the year.

In various portions of the grounds about 3,300 square feet of cobble-stone gutters have been laid and about 540 feet of brick gutters repaired.

A new drain 140 feet long, of 8-inch terra-cotta pipe, has been laid in a trench 3 feet deep and a new trap constructed connecting the gutters with this drain.

During the summer season sprinkling carts were used regularly to keep down the dust on the drives.

All sidewalks around the reservation have been kept free from weeds and in as good order as possible; all dead wood has been cut from trees and shrubs and five dead trees removed.

By authority of the War Department sacred concerts were permitted in these grounds on Sunday afternoons in May, 1887. They were largely attended by a class of our industrious fellow-citizens whose duties during the week prevent them from attending concerts at other times.

I consider this plan of Sunday concerts admirable and trust they will be continued. I can imagine no better use to which our public parks can be placed than that of aiding the rational enjoyment on Sunday of those of our people whose entire time is occupied on week days with their labors.

HENRY (ARMORY) PARK AND SEATON PARK.

These parks have been improved as far as funds would admit and have been maintained in good order during the year.

All grass surfaces have been mown from time to time, all roads and paths raked, rolled, and repaired, and gutters and drain traps cleaned.

In Henry (Armory) Park, the construction of the mound around the Baltimore and Potomac depot has been continued and about 12,000 cubic yards of earth placed upon it and the southern extremity graded.

The railroad company, by authority of the Secretary of War, has constructed an ornamental stone wall along the western boundary line of that portion of the reservation used for depot purposes by authority of an act of Congress.

The lawn surfaces at various localities where the grass had been destroyed by trespassers was resodded; the two stone pillars on the line of the iron fence on the north boundary of the park were repaired and painted; the grounds near the Armory Building were graded, partly sodded, seeded down, and a number of evergreen trees planted.

The circle in front of the Armory was graded, a handsome willow-tree planted in the center and surrounded with flowers.

In the northwest portion of Seaton Park, a new drain of 128 feet of 8-inch terra-cotta pipe was placed in position and the gutters connected with it by means of three new sewer-traps.

The old brick house in the park, near Four-and-a-half street and Missouri avenue, which in its dilapidated condition had for many years

been far from ornamental, and which was of no use in that locality, was torn down and the brick used for other purposes on the public grounds. The wood-work was so far decayed as to be utterly worthless. A handsome lodge for the watchman was constructed in the southwest section of the park, near Maine avenue.

The lawn surfaces were repaired at various localities by resodding where the grass had been destroyed by trespassers.

Every effort was made to keep these handsome parks in good order though extensive improvements are still necessary to maintain the beauty which their prominence demands.

It is earnestly urged that a special appropriation be made for completing the mound around the depot and planting it with trees, and for the construction of an asphalt walk along the sides of the main road between Third and Seventh streets.

RESERVATIONS NORTH OF PENNSYLVANIA AVENUE AND WEST OF THE CAPITOL.

This division of the city comprises fifty-six highly and partially improved reservations, covering an area of about 108 acres and located between First and Twenty-eighth streets west and B and Q streets north. It includes the highly improved parks known as Washington Circle, Rawlins Square, Dupont Circle, Scott Circle, Lafayette Square, Franklin Square, Farragut Square, McPherson Square, Mount Vernon Square, Iowa Circle, Thomas Circle, and Judiciary Square.

During the year the lawns have been mown twice each month between June 1 and November 30, and watered during the dry season; the margins edged and trimmed; the gutters and drain-lodges cleaned out once each month; the roads and paths weeded, raked, and rolled once in two months; the trees and shrubs pruned, cleared of caterpillars, and the young trees and shrubs and flower beds watered during the dry season; new trees and shrubs were planted and beds of ornamental foliage, flowering and tropical plants set out. This is a part of the regular annual work, and is necessarily mentioned in the yearly reports.

During the winter a large amount of compost was prepared and spread over the lawns of the various parks, and raked therefrom in the spring.

After the removal in the autumn of the summer flowering and foliage plants, 26 beds in the various parks were planted with blooming chrysanthemums, and still later 27 beds in Lafayette, Thomas, Scott, Dupont, Franklin, and other improved reservations were planted with 17,000 bulbs of various kinds, adding greatly to the beauty of the parks when they bloomed in the early spring.

During the winter season plank footwalks were laid on regular lines of travel through the south grounds of the Executive Mansion, Washington Circle, Franklin and Mount Vernon squares.

At Franklin Square 168 square yards of asphalt walks were laid, connecting I and K streets through the middle of the square, and in Mount Vernon Square 256 yards of similar paths were laid on the line of Eighth street. All the gravel paths in these squares were also repaired and improved.

The statue of General Rawlins was removed from Rawlins Square by authority of an act of Congress, and the two large vases formerly on each side of the statue were transferred, the one to the reservation at the corner of Massachusetts avenue and Twentieth street, and the other to Marion Reservation on South Carolina avenue, between Fourth and Sixth streets east.

The former site of the statue was cleared of foundation stone, filled ith soil, and sodded over.

Two unimproved and one partially improved reservations have been ighly improved by grading, sodding, and planting with trees and ırubs. Two of them have been inclosed with posts and chain fences. hey are as follows:

Reservation No. 20, corner of Pennsylvania avenue and Twenty-ghth street northwest, containing an area of 3,502 square feet. The ost and pipe rail fence, badly broken, was removed from the reserva-on and four willow trees overhanging the fountain were cut down. ew gravel walks with granite curbing were constructed around the ountain; the lawns were graded and sodded, and a large, handsome iron ase placed in position and filled with flowers.

Reservation No. 132, corner of Twentieth and Q streets northwest, ontaining an area of 8,536 square feet. The surface of this reserva-ion was reduced to conform to the grades of adjacent streets, and it as surrounded with a post and chain fence; 500 cubic yards of clay ere removed and 200 cubic yards of good soil deposited on the reser-ation; the lawn was seeded down, the margins sodded, and 80 orna-nental flowering shrubs, 6 evergreen, and 6 deciduous trees planted. he reservation is now highly improved.

Reservation No. 171, at the intersection of New Jersey avenue, Second, and I streets, containing an area of 5,725 square feet. This eservation was graded and sodded, water introduced, and gravel aths constructed across it; 110 flowering shrubs were planted on the awns and the small park surrounded with a post and chain fence, thus ompleting, with the triangle opposite to it, a very handsome improve-ment in this section of the city.

At the close of the fiscal year the various improved reservations in this livision of the city, north of Pennsylvania avenue and west of the Cap-itol, with the exception of a portion of Judiciary Square around the new Pension Building, were in excellent condition.

RESERVATIONS EAST OF THE CITY.

The improved reservations in this section of the city consist of Lincoln Square, Stanton Square, Folger Square, Marion Square (South Carolina avenue between Fourth and Sixth streets east), and a number of smaller parks on Pennsylvania avenue, Maryland avenue, and Delaware avenue.

To these reservations No. 48 has been added during the year.

This reservation, at the intersection of Pennsylvania avenue and South Carolina avenue east, contains an area of 13,523 square feet; previous to its improvement it was used as a dumping-ground for refuse; it was properly graded, surface coated with good soil, edges sodded, and lawn sown down with grass seed; a handsome flower-bed was planted.

Reservation No. 49, immediately opposite No. 48, containing an area of 15,344 square feet, was surrounded by a post and chain fence, and a flower-bed planted in it.

Reservations Nos. 35 and 36, heretofore highly improved, the one containing an area of 8,544 square feet, the other an area of 5,994 square feet, were transferred to the Library Commission for the site of the new Congressional Library.

During the coming year reservations 48, 49, and 50 will be planted with trees and shrubs, and it is hoped that funds will admit of the im-

provement of one or more additional reservations in this section of the city.

The improvement of the large reservation on South Carolina avenue between Fourth and Sixth streets east, containing an area of about 1.6 acres, was completed during the year; the gravel walks of this park cover an area of about 1,500 square yards, and the lawn surfaces about 6,300 square yards.

It is recommended that this park, situated on South Carolina avenue, be hereafter known as "Marion Park," in memory of the distinguished soldier from South Carolina who served his country so gallantly in the war of the Revolution.

The usual care was given to all improved reservations throughout this section of the city; the large parks and many of the smaller ones were surface-coated with compost during the winter, about 1,000 cubic yards having been used for this purpose; all lawns were mown and raked from time to time, paths and roads raked, repaired, and rolled, lawns edged, gutters and drain-traps cleaned, trees and shrubs pruned, mulched, and watered, flower-beds laid out and planted, and about 2,600 bulbs set out in Lincoln and Stanton squares.

Unfortunately, we have had much trouble in protecting our flower-beds in these parks. Plants and bulbs were frequently pulled up by the roots at night after the watchmen had gone home. On one occasion forty hyacinths were plucked from a bed in Stanton Square. Much annoyance has also been caused by chickens running at large and destroying the lawns and flower-beds. The law appears to grant no protection in the latter case.

The various fountains have been repaired and put in good working order, and the drain-pipes in Lincoln Square, occasionally clogged by roots, have been taken up, cleaned out, and replaced.

At the close of the year all improved reservations in this section of the city were in good order.

RESERVATION NO. 17, GARFIELD PARK.

This reservation, situated south of the Capitol, between South Capitol street and Third street east, contains an area of about 24 acres. It is located in a section of the city which, up to this date, has not been highly improved by private enterprise.

The work of improvement was commenced in 1883, and up to this time the sum of $90,000 has been appropriated, of which $78,500 has been expended, $1,500 returned to the Treasury, and $10,000 is at this time, July 5, 1887, available.

The original estimate of cost of the improvement was $135,000; it will require further appropriations of $45,000 to complete the work, of which $10,000 can be profitably expended during the next fiscal year.

Operations during the past year have been mainly devoted to the eastern division of the park, which is now nearly completed. Virginia avenue, as it passed through this section, was closed and the south-eastern portion of the park, covering an area of about 4 acres, was graded to correspond with the city grade of H street south; a side-walk of gravel, 12 feet wide, was constructed along H street between First and Third streets, and about 1,000 linear feet of curbing placed in position.

Nine hundred linear feet of roadway, 30 feet wide, covering an area of 3,000 square yards, and 891 linear feet of gravel paths, 10 feet wide, covering an area of about 1,000 square yards, were constructed.

About 2,000 cubic yards of gravel and 300 cubic yards of broken stone were used in these roads.

In grading the park about 11,000 cubic yards of earth, clay, gravel, and sand were excavated and moved, about 6,000 yards of which were dumped as refuse some distance from the park and the remainder used in the improvements in progress.

At different portions of the reservation there were laid 152 square yards of brick pavement, 100 square yards of cobble and blue stone gutters, and 144 square yards of trap-rock pavement; 915 linear feet of drain-pipe was laid in trenches to carry off the water from springs to the sewers.

About 5,000 cart-loads of soil were used on the lawn surfaces of the regraded section, and these lawn surfaces were sown with grass seed, harrowed, and rolled; about 700 square yards of sod were laid on the margins of roads and on the southern boundary of the reservation.

Much attention has been given during the year to planting; 2,120 deciduous and evergreen trees and shrubs were set out, and the reservation now contains some of the handsomest specimens in the public grounds.

During the coming year it is proposed to entirely complete the improvement of the eastern section and to continue the improvement of the western section of the park.

PUBLIC RESERVATIONS OCCUPIED BY THE BALTIMORE AND POTOMAC RAILROAD COMPANY.

Attention is invited to the recommendation in my last annual report in reference to reservation No. 101.

This reservation, lying just south of the Smithsonian Park, contains about 2½ acres and is unimproved; it is partly occupied by the Baltimore and Potomac Railroad Company, the tracks of which run through the reservation. The laws under which the company claim authority for their occupancy are fully set forth in my last annual report.

The return of the reservation to the purpose for which it was originally intended, namely, a public park for the adornment of the city, is greatly desired by citizens living in the vicinity.

I renew the estimate of $3,000 submitted last year for the improvement of this reservation. If the appropriation is made, it should be coupled with the provision that the track running through the grounds across Seventh street into Maryland avenue shall be at once removed by the railroad company.

Attention is invited to the fact, that without authority of law, and in my opinion in direct violation of section 222 of the Revised Statutes relating to the District of Columbia, the Baltimore and Potomac Railroad Company is now occupying United States Reservations Nos. 174, 178, 241, and 309.

I have reported fully, from time to time, the facts of the occupancy of the reservations by the railroad company and was informed, under date of February 19, 1887, by the United States district attorney for the District of Columbia, that the Attorney-General of the United States had referred the papers in the case to him and instructed him "to institute such proceedings as the facts of the case warrant and as may be necessary for the enforcement of the law against the company and the maintenance of the rights and interests of the United States in the premises."

I am not aware whether any action has been taken in the case up to this date.

It certainly appears that something should be done to protect th property of the United States from being thus occupied by the railroa company without authority of law.

SETTEES, IRON FENCES, TOOLS, MANURE, ETC.

One hundred new park settees of improved pattern were purchase during the year and distributed throughout the parks; 108 old settee were repaired and painted, and 318 repainted. At the close of the fisca year there were 1,637 settees on hand, located as follows:

Location.	No.	Location.	No.
Washington Circle	59	Farragut Square	4
Dupont Circle	56	Franklin Square	12
Lafayette Square	172	Mount Vernon Square	5
Iowa Circle	79	Grounds south of Executive Mansion	8
Executive Mansion Grounds	106	Henry Park	3
Smithsonian Park	316	Folger Park	2
Seaton Park	69	Stanton Square	4
Lincoln Square	103	Judiciary Square	7
McPherson Square	65	Various smaller reservations throughout the city	113
Rawlins Square	30		

Post and chain fences have been erected around the reservations at Q and Twentieth streets, New Jersey avenue and Second street, and Pennsylvania avenue and Ninth street east; minor repairs have been made to the fences from time to time when necessary.

The iron fences, lamp-posts, drinking fountains, vases, etc., were repainted at the Executive Mansion Grounds, Lafayette Square, Franklin Square, and a number of smaller reservations throughout the city; the stone pillars of the fences around the Smithsonian and Henry (Armory) parks were repaired and painted.

About 1,000 cubic yards of soil and 1,000 cubic yards of manure were purchased and thoroughly incorporated into rich compost; this, with what remained on hand from last year, amounting in all to about 2,500 cubic yards, was used in spreading over park lawns and around trees and shrubs. In addition to this a ton of ground oyster shells was purchased and used as a fertilizer upon the lawns.

A blacksmith and helper were employed during the year repairing tools in daily use, and new tools were purchased from time to time when needed.

A large temporary force was employed after each snow-storm during the months of December, January, February, and March removing snow and ice.

There were ten snow-storms of more or less violence requiring the removal of snow immediately after their cessation. As a single example, that of December 4 and 5 is given. The snow commenced falling on Saturday afternoon, December 4, and continued until noon on Sunday; began again Sunday night and continued until noon on Monday; the total fall was very heavy for this latitude. To remove this snow required the labor of 155 men two and a quarter days, at a total cost of $406, or one-third of the entire appropriation for the year. This was the severest storm of the season and the expense incident to removing snow after the other storms was fortunately much less. The total length of the paths and sidewalks under supervision of this office, from which snow must be removed after each storm, is about 16 miles, the area being about 30 acres. Owing to the small appropriations heretofore made,

the work is not always done satisfactorily and frequently only one-half the sidewalk is cleaned off; this causes complaint from citizens, who blame the officer in charge for not doing better, when he is doing all that is possible with the means at his command. It is earnestly recommended that the annual appropriation hereafter be increased to $1,500.

FOUNTAINS.

There are 21 fountains with basins in charge of this office, located as follows: Executive Mansion Grounds, 2; Lincoln Square, 2; Stanton Square, 2; Rawlins Square, 2; and 1 each in Folger Square, Judiciary Square, Mount Vernon Square, Franklin Square, Iowa Circle, and the reservations at Massachusetts avenue and Twentieth street, New York avenue and Third street, New York avenue and Tenth street, Pennsylvania avenue and Ninth street, Pennsylvania avenue and Nineteenth street, Pennsylvania avenue and Twenty-first street, Pennsylvania avenue and Twenty-eighth street, and Delaware avenue and First street east. There are 25 drinking fountains in the various parks.

The fountain at Franklin Square has been entirely overhauled and improved; that at Judiciary Square has been moved to a new position to correspond with the improvements around the Pension Building, and entirely rebuilt, and extensive repairs have been made to that at Mount Vernon Square. Repairs have been made from time to time to all the fountains, much trouble having arisen from injury to the drains by sticks and stones thrown in by children.

Owing to the limited supply of water it has been necessary to restrict the flow of all fountains, except those at the Executive Mansion Grounds, to the hours between 5 and 7 p. m. daily.

WATER-PIPES AND FIRE-PLUGS.

The necessary care was bestowed upon the water-pipes during the year. In the autumn the water was shut off from the parks, the hose-valves removed and stored for the winter; the valves were replaced in the spring and water turned on.

Repairs were made from time to time to the pipes conveying the water from the spring near the Soldiers' Home to the Capitol, and a full supply of clear spring water for drinking purposes was maintained at the Capitol; it is understood that this pipe has been tapped in years past by private parties; but up to this time I have been unable to find out where the main has been cut.

It is proposed to remove the old pipe, which is now badly rusted and very thin, and to replace it with a new one; this will be done by degrees from annual appropriations, and an effort made to cut off the supply of all who are using the water without proper authority.

Water-pipes were laid and water introduced in eight reservations, as follows: Pennsylvania avenue and Fourteenth street, Pennsylvania avenue and Thirteenth streets, Pennsylvania avenue and Ninth street, Pennsylvania avenue and Seventh street, Maryland avenue and First street east, Maryland avenue and Third street east, New Jersey avenue and Second street, and Judiciary Square. The total length of pipe used in this work was 906 feet. The pipes in the Executive Mansion Grounds were extended by adding 109 feet. One thousand one hundred and fifty feet of rubber hose was purchased and used in connection with the extension of water-pipes.

It is recommended that a fuller supply of water be furnished for the Executive Mansion; this can be easily done by running a 12-inch main

from the mansion up Sixteenth street and connecting it with the 36 inch main on L street; the cost will not exceed $5,300. At present pumps are necessary to drive the water to the roof to fill the tanks that supply the closets, hot-water boilers, and for running the elevator.

PARK LAMPS AND LIGHTING.

The usual attention was given to the lamps during the year. The lamp-posts were repainted and lanterns reglazed and cleaned when necessary; one additional lamp was erected in Farragut Square.

An additional meter was placed in the Executive Mansion and improvements made in the method of introducing gas into the building.

There are in all 406 lamps, with 481 burners, belonging to this Department.

The average number of lamps not connected with meters, burning nightly during the year, was 322; each lamp burned about 2,600 hours and consumed about 15,600 feet of gas. In addition to these there were 71 lamps within the Executive Mansion grounds connected with the meter of the mansion.

Attention is invited to the fact that the grounds south of the Executive Mansion, known as the White Lot, are without lamps of any kind. It is recommended that a tower about 150 feet high be erected in the center of the ellipse, from the top of which there shall be shown six arc lamps of 2,000 candle-power each. The tower should be of the best lap-welded tubing, with malleable iron fittings and diagonal brace-rods.

Such a tower, to be constructed upon plans and specifications now on file in this office would cost about $750. It can be illuminated from dusk in the evening until daybreak the next morning, every night in the year, for 70 cents per lamp per night, or at the rate of $1,533 per annum for the 6 lamps; it is believed that it will shed a soft, mellow light over the entire grounds, including those within the fence on the south side of the Executive Mansion. Its construction is recommended.

IMPROVING GROUNDS AROUND THE NEW PENSION BUILDING.

The work of improving these grounds was commenced early in September and pushed forward as rapidly as possible.

The greater portion of clay and earth which had been excavated from the site of the new building and piled around it was removed and the grounds reduced on the south and part of the east side to conform to surrounding grades.

Seven thousand six hundred and forty cubic yards of clay and earth were broken up, hauled away, and deposited on the mound now in course of construction around the Baltimore and Potomac Railroad depot.

On the south front of the Pension Building lawns were laid out, seeded and sodded on their borders; a new cariage road 30 feet wide was made on the line of F street between Fourth and Fifth streets, and a gravel walk 16 feet wide, extending from street to street along the entire south front of the main building, was constructed.

The fountain basin was removed to a position opposite the middle of the main building and a gravel road 20 feet wide constructed around it, to form a suitable carriage approach to the southern entrance; about 2,000 cubic yards of gravel and 500 cubic yards of broken stone, brick, etc., were used in the construction of these roads and paths.

In the construction of lawn surfaces about 4,500 cubic yards of earth and soil from these grounds and 1,000 yards of soil from other locali-

ties were used in surface grading and filling; about 1,500 square yards of lawn surface was sodded and the remainder seeded down with rye and grass seed and rolled.

Much work is required to complete the improvements around the Pension Building; all roads and paths within the reservation and immediately surrounding the building should be of asphalt, as otherwise the dust arising from gravel roads in summer and the mud in winter, will be a source of great discomfort to those employed in the Pension Bureau.

In the other portion of Judiciary Square the roads and paths have been repaired and rolled, gutters and drain-traps cleaned, lawns mown, flower-beds laid out, and every every effort made to keep the reservation in as good order as possible.

It is earnestly recommended that an appropriation be made for constructing asphalt walks leading through the park to the City Hall; these paths are continually used by the large number of citizens doing business with the courts and in winter time they are very muddy and in bad condition.

I strongly urge that the appropriation requested for this reservation may be made; it includes the completion of the grounds around the Pension Buiding, except asphalt roads, the construction of asphalt walks leading to the City Hall, and the maintenance of the remainder of the reservation in proper condition.

REMOVAL OF STATUE OF GENERAL RAWLINS.

By the act of Congress approved May 17, 1886, the sum of $500 was appropriated for the purpose of removing the statue of General John A. Rawlins from its location in Rawlins Square to such site as the Secretary of War should select. Early in August, 1886, the Secretary of War directed that the statue be transferred to the reservation at the southeast corner of Pennsylvania avenue and Ninth street northwest.

Proposals were at once invited for removing the statue and pedestal, and in September the contract was awarded to the Washington Granite Monumental Company. Work was commenced September 22 and prosecuted very satisfactorily, and by the middle of October the removal of the pedestal and statue and their erection upon a firm concrete foundation at the new site was completed. By authority of the Secretary of War the grounds immediately around the statue were highly improved and about 95 square yards of asphalt walks constructed; the name "Rawlins" was cut upon the pedestal. The entire work was done in a complete and satisfactory manner.

EXECUTIVE MANSION.

The following work was done at the Executive Mansion during the year:

The entire outside of the house, together with the iron railing immediately in front of it, the wood work of the entire parlor floor, that of six rooms and the hall on the second floor, that of the kitchens, laundry, two bedrooms, and closets on the basement floor, the pipes of the elevator shaft and those in the pump-room were repainted and different portions of the other rooms touched up with paint where necessary.

The area in front of the mansion and under the north and south balconies, the elevator shaft, the elevator pump room, the corridor and rooms under north balcony, and the entire basement floor, including

kitchens and laundry, were whitewashed, the ceilings o on the second floor were calcimined and the cornices rious rooms; the ceilings were repapered in seven ro and bedroom floor, one bedroom entirely repapered ar of the blue bedroom recolored.

A new skylight and ventilator were placed in the ro and ventilate the corridor of the second floor.

Extensive additional arrangements were made for a st the entire lighting system of the mansion and grounds put in order; new supply pipes were introduced in the

The gas engine for pumping water to the supply tanks put in order, and extensive repairs made to the pump t elevator tank; the elevator was overhauled, revarnis complete order.

New carpets were placed in the East Room, private d between East Room and main vestibule, and one bedroo was placed in one bedroom, on the hall between the di on the stairs leading therefrom to the second story; tw lace curtains were purchased for the East Room an second floor, to replace those which were falling to pie

New mats were purchased for the front door and ves

One room on the second floor was refurnished, the ol used for the small reception room on first floor, and throughout the house.

A wooden and glass partition was erected in the corr floor to separate the official and private portions of the

All carpets, about 3,500 yards, were taken up, shake summer and relaid in the autumn; all curtains, 61 p down, repaired, the laces that were fit for future use put up again in the autumn. The furniture in the East Parlor was repaired and a portion of it reupholstere additions were made to the table and kitchen ware, a and general repairs were made to doors, windows, sasl

The mansion was elaborately draped in mourning in in respect to the memory of Ex-President Arthur; a of materials were used for this purpose. All furnaces and chimneys were cleaned, and repaired where nec plete set of awnings was purchased for use during the w

The usual care was bestowed upon the greenhouses tory was overhauled, new asphalt and granolithic pave heating and ventilating apparatus introduced, all de removed and replaced with new as far as funds would and iron benches and new water-tanks introduced, and and outside repainted. All the other greenhouses were r and put in order as far as funds would admit, and nev plant tables introduced into the old rose-house.

No new structures of any kind have been erected, has been made to keep those which were constructed pr 1885, in good order. Considerable repairs have been ma and a new asphalt pavement placed over a portion of the the two wings.

In the grounds of the mansion the lawns were reg raked, paths and roads repaired and rolled, trees an mulched, and watered, flower-beds laid out and planted foliage and flowering plants, new trees and shrubs s dead ones removed.

Some valuable plants have been stolen from the grounds during the year.

The fountains were repaired and maintained in good order during the year.

TELEGRAPH TO CONNECT THE CAPITOL WITH THE DEPARTMENTS.

The telegraph lines now under control of this office are as follows:

The line of overhead wires consists of 77 poles covering a distance of about 3½ miles, with a length of about 8 miles of wire; this line, starting from the northwest corner of Seventeenth and G streets, runs over the State, War, and Navy Building to the Executive Mansion, thence to the Treasury Building, thence to G street, thence to Eighth street, thence to H street, thence to North Capitol street, and thence to the Capitol; connected with this line is one running from the Treasury Department along Fourteenth street to the Bureau of Engraving and Printing and one from H street down Fifth street to the new Pension Building.

There is about 500 feet of 13-conductor Patterson cable running from the cable pole in the Capitol Grounds into the basement of the Senate, and 250 feet of 20-conductor cable running from the cable pole on the corner of Seventeenth and G streets into the State, War, and Navy Building.

The underground cable now in use, known as the Waring anti-induction cable, consists of two 6-conductor cables, running from the Office of Public Buildings and Grounds to the United States Senate and House of Representatives, a distance of 2.6 miles; this cable runs down Seventeenth street to New York avenue, through the grounds south of the Executive Mansion to Fifteenth street, along Fifteenth to B street, along B to Sixth street, thence to Missouri avenue, along Missouri avenue to Third street, along Third to Pennsylvania avenue, along Pennsylvania avenue to First street, along First to B street, thence to North Capitol street and though the old conduit into the Capitol Building; about 1,500 feet of cable runs through the Capitol, about 1,200 feet through the State, War, and Navy Building, and about 300 feet is used in connecting the Executive Mansion with the main cable.

The offices connected with these lines are as follows: Executive Mansion, United States Senate, United States House of Representatives, Treasury Department, State, War, and Navy Departments, Department of Justice, Post-Office Department, Department of the Interior, New Pension Building, Government Printing Office, Signal Office, National Museum, and Office of Public Buildings and Grounds. Each office has two circuits and two sets of instruments, except the Signal Office; the Museum and the new Pension Building each has from two to four cells in the local battery. The main battery, located in the Office of Public Buildings and Grounds, has 68 cells for the overhead wires and 29 cells for the underground cable.

During the year the main and local batteries were maintained in good condition and all crosses and obstructions of every kind were removed from the wires as rapidly as possible.

The Government wires, formerly attached to the poles of the Western Union Company along Seventh street, were removed and run over the Department of the Interior and the Post-Office Department buildings.

The old line of poles running from Seventeenth street and Pennsylvania avenue up Seventeenth street to I street, thence along I to Fourteenth street and along Fourteenth street to G street, being no longer needed, the wires were removed and the poles used to replace decayed ones else-

where along the line. Eight poles on North Capitol poles on H street between Fourth and Seventh stree from the old to the new curb lines and the wires chan poles were erected in the places of old and decayed on

A new line was run along the fire-alarm poles fron Fifth street to the new Pension Building and that bui with the general system.

All the cables in the basement of the Capitol were put in good working order; about 300 feet was taken way for improvements in the summer of 1886, and autumn; the instruments connected with the Unite Chamber and House of Representatives were removed of Congress and replaced at the commencement of the

About 70 feet of cable on the roof of the Executive had become damaged by water through the vandalism tore off the top of the cable box, was removed and rep lated wire. All instruments, switch-boards, etc., were ke and at the close of the fiscal year the entire telegraph excellent condition.

I again submit an estimate for replacing the entire with a duplicate six-conductor under-ground cable. Th are not only a nuisance to which the public should n jected, but the growth of trees on the sidewalks alo reached such a condition that during wet or windy w are almost useless. Unless the entire line be placed und built with higher poles during the next year there will sions when it will be impossible to maintain telegraphic

To remove the entire overhead system and replace it under-ground cable will cost $8,500; to replace the pr with poles 55 feet long, so as to carry the wires for the tops of the trees, will cost about $1,600.

The overhead wires should be removed, and if the Un ernment takes the initiative, private corporations can low its example.

In the discharge of my official duties connected wit lines I have received intelligent and efficient assistanc Kennedy, the electrician on duty in this office.

SURVEYING AND DRAUGHTING.

The duties of the only draughtsman allowed this o to be present in his office during the greater portion o hibit the old public records of Washington City to tho is frequently summoned to produce these records in th

During the six months from January 1 to June 30, tions given to him from the office of the Secretary of W man has been engaged a large portion of his time assi States district attorney in searching the records for reference to the rights of the United States in the case Kidwell Flats.

During the year, in addition to the duties performe United States district attorney, he has prepared a com of all United States reservations under charge of thi with a map showing their location, and has also prepar the lines of the tracks of the Baltimore and Potomac through United States reservations; surveys and pla made of several miner reservations throughout the cit

It will be observed that the time of the draughtsman is mostly occupied with the care of the old records, and it is earnestly urged that Congress will provide a clerk who may devote his entire time to this important branch of the duties of this office.

NUMBER AND AREA OF RESERVATIONS AND STATUES.

Condition, number, and area of reservations.

Description.	Number.	Area.
		Acres.
Total number of reservations	331	413.52
Reservations highly improved	55	231.28
Reservations partially improved	47	110.55
Reservations unimproved	229	71.69

Four have been added to the list of highly improved and one to the list of partially improved during the year.

Those added to the highly improved were the reservations at the intersection of Pennsylvania avenue and M street; the intersection of Twentieth and Q streets; the intersection of New Jersey avenue and Second street, and the intersection of Pennsylvania avenue and Ninth street east. The partially improved is at the intersection of Pennsylvania avenue and Eighth street east.

There are now twelve statues in the public grounds, as follows: Washington, Greene, Jackson, Lincoln, Scott, Farragut, Thomas, Du Pont, Rawlins, McPherson, Garfield, and Henry.

The Garfield statue has been erected during the year, and the names cut on the pedestals of the statues of Washington, Jackson, Rawlins, Du Pont, Farragut, and Scott. The inscription ordered by Congress just after the death of General Greene, in 1786, has been cut upon the pedestal of the statue erected to his memory. It is as follows:

Sacred to the memory of Nathaniel Greene, esquire, a native of the State of Rhode Island, who died on the 19th of June, 1786, late major-general in the service of the United States, and commander of their forces in the Southern Department.

The United States, in Congress assembled, in honor of his patriotism, valor, and ability, have erected this monument.

TREES AND SHRUBS.

In my last annual report I submitted a list of the deciduous and evergreen, native and foreign, trees and shrubs, forming the ornamental planting of the various parks of the public grounds under charge of this office. The list embraced a majority of the species and varieties generally known that will thrive in the climate of Washington, and comprised in the aggregate over 32,000 specimens of deciduous and evergreen trees and shrubs. About 2,500 specimens have been added by planting in the grounds during the past year. It is the purpose of this office to continue annually adding to the beauty of the grounds by planting varieties of decided merit.

In the early planting of the grounds the trees were planted close together, anticipating that in time it would be necessary to thin them out. This is done with great care, and unless a tree is in very bad condition or is manifestly injurious to better and handsomer trees in the immediate vicinity it is never disturbed.

During the summer of 1886 the trees throughout the city were infested with caterpillars, which in numerous instances completely stripped them

of leaves. A number of men were employed in the parks removing webs and the leaves and smaller branches upon which the worms congregated.

In February and March men were again sent through the parks about 60,000 cocoons were destroyed. Many of these contained the web-worm in the quiescent state, while a large number were the pend bags of the bag-worm. Of these latter many contained several hund eggs; others were the empty shells of the male pupa, while others w the old bags of previous years.

The cocoons were found hanging to trees, in the crevices of the ba under and upon the wooden benches, and under the tops of the pos of the iron fences.

As soon as the young caterpillars again appeared in June, 188 small force was set at work removing the webs and the leaves up which they were congregating and destroying them.

In this way, at a comparatively small expense, the parks have be partially freed from these pests, and the damage done the trees a shrubs under charge of this office has been comparatively small.

ESTIMATES FOR THE FISCAL YEAR ENDING JUNE 30, 1889.

Salaries of employés public buildings and grounds etc:		
For one office clerk	$1,600	
For one messenger	840	
For one public gardener	2,000	
For one clerk in charge of old public records of Washington City	1,500	
For one electrician and telegraph lineman	1,000	
For overseers, foremen, draughtsman, gardeners, mechanics and laborers	30,000	
For one day watchman at Lafayette Square	720	
For one day watchman at Franklin Square	720	
For two day watchmen in Smithsonian Grounds at $660 each	1,320	
For two night watchmen in Smithsonian Grounds at $720 each	1,440	
For one day watchman at Judiciary Square	660	
For one day watchman at Lincoln Square and adjacent reservations	660	
For one day watchman at Iowa Circle	660	
For one day watchman at Thomas Circle and neighboring reservations	660	
For one day watchman at Washington Circle and Rawlins Square	660	
For one day watchman at Du Pont Circle and neighboring reservations	660	
For one day watchman at McPherson and Farragut Squares	660	
For one watchman at Stanton Square and neighboring reservations	660	
For two day watchmen at Henry (Armory) and Seaton Squares and reservations east to the Botanical Gardens, at $660 each	1,320	
For one night watchman at Henry (Armory) and Seaton Squares and reservations east to the Botanical Gardens	720	
For one day watchman at Mount Vernon Square and adjacent reservations	660	
For one day watchman at grounds south of Executive Mansion	660	
For one watchman for green-houses and nursery	660	
For one day watchman for Marion Square, Folger Square, and adjacent reservations	660	
		$51,1
For contingent and incidental expenses	500	
For rent of office of Public Buildings and Grounds	900	
Improvement and care of public grounds:		
For improvement of grounds north of the Executive Mansion	2,500	
For improvements and maintenance of grounds south of the Executive Mansion	6,000	

Improvement and care of public grounds—Continued.		
For ordinary care of green-houses and nursery	$2,000	
For ordinary care of Lafayette Square	1,000	
For ordinary care of Franklin Square	1,000	
For care and improvement of Monument Grounds	5,000	
For continuing improvement of Reservation No. 17 and site of old canal northwest of same	10,000	
For construction and repair of post-and-chain fences and removal of high iron fences from around smaller reservations	1,500	
For laying asphalt walks in various reservations	10,000	
For manure and hauling same	5,000	
For painting watchmen's lodges, iron fences, vases, lamps, lamp-posts and settees	2,000	
For purchase and repair of seats	1,000	
For purchase and repair of tools	2,000	
For trees, tree and plant stakes, lime, whitewashing and stock for nursery	3,000	
For removing snow and ice	1,500	
For flower-pots, twine, baskets, wire, splints, moss, and lycopodium	1,000	
For care, construction, and repair of fountains	1,500	
For abating nuisances	500	
For improvement, care, and maintenance of various reservations.	20,000	
For improvement, care, and maintenance of Smithsonian Grounds, including construction of asphalt roads and paths	12,000	
For improvement and care of Henry and Seaton Parks, east to Botanical Gardens	5,000	
For improvement, care, and maintenance of Judiciary Square, including grounds around new Pension Building and asphalt walks leading to the City Hall	10,000	
For an ornamental structure of masonry and iron over the spring in Franklin Square	2,000	
For lodges for park watchmen in Stanton, Mount Vermon, Iowa, Du Pont, Thomas, McPherson, and Folger reservations, at $500 each	3,500	
For improvement of Reservation No. No 101 (provided that this sum shall not be available until the track running diagonally through the reservation along the line of Maryland avenue shall have been removed by the railroad company now in charge of it, which company is hereby required to remove said track on or before October 1, 1888)	3,000	
For supplying and keeping supplied the 76 vases in the new Pension Building with suitable plants and shrubs and caring for same, in accordance with the joint resolution of Congress approved March 29, 1886	1,000	
For continuing the carriage roadway on the prolongation of Sixteenth street through Lafayette Square to Pennsylvania avenue	4,000	
		$117,000
Care of, repairs, fuel etc., Executive Mansion:		
For care, repair, repainting and refurnishing the Executive Mansion	16,000	
For fuel for Executive Mansion, green-houses, and stable	3,000	
For care and necessary repair of green-houses	5,000	
For renewing superstructure of one green-house connected with Executive Mansion and grounds	1,500	
		25,500
Lighting the Executive Mansion and the public grounds:		
For erecting tower in the ellipse south of the Executive Mansion from the top of which there shall be shown an electric light from six arc lamps of 2,000 candle-power each	750	
For electric light for 365 nights from six arc lamps of 2,000 candle-power, at $4.20 per night	1,533	
For gas, pay of lamp-lighters, gas-fitters and laborers, purchase, erection and repair of lamps and lamp-posts, purchase of matches and repairs of all kinds; fuel and lights for office and office stable, for watchmen's lodges, and for green-houses at the nursery	14,000	
		16,283

Repairs to water-pipes:		
For repairing and extending water-pipes, purchase of apparatus for cleaning them, purchase of hose and for cleaning the springs and repairing and renewing pipes of same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments	$2,500	
For furnishing a full supply of water for all purposes to the Executive Mansion by connecting the Mansion by a 12-inch main with the 36-inch water main on L street	5,300	
		$7,800
Telegraph to connect the Capitol with the Departments and the Government Printing Office:		
For replacing the entire overhead system of wires with duplicate six-conductor underground cable, being a total distance of about 11,500 linear feet; 23,000 feet cable, at 24 cents per foot.	5,520	
Ditching, boxing, etc., 11,500 feet, at 20 cents per foot	2,300	
Labor inside of buildings	280	
Contingencies, about 5 per cent	400	
	8,500	
For care and repair of existing lines	1,500	
		10,000
Total		229,083

In submitting these estimates, some of which are larger than heretofore appropriated and some for new work, the following explanation is presented:

First. One public gardener, $2,000. I have asked for an increase in the salary of the public gardener, a position now so satisfactorily filled by Mr. George H. Brown. The duties of the office require that the gentleman who fills it shall be thoroughly skilled in the culture of trees, shrubs, and plants, and shall have a practical knowledge of civil engineering as applied to landscape gardening. Mr. Brown combines these attributes, to which he adds taste, industry, and integrity. His duties take him from one end of the city to the other. He is directly responsible for the care of the valuable collection of plants in the propagating garden, and superintends the propagation of plants that are annually raised for the public grounds, which this year numbered about 290,000.

Second. One clerk in charge of old public records of Washington City, $1,500.

These records include maps, deeds, record-books, letters, etc., from the organization of the original Board of Commissioners near the close of the last century up to 1867, when the duties were turned over to the Chief of Engineers.

It is necessary that they shall be stored in a building as near fire-proof as it is possible to procure; for many years they were kept in the basement of the Capitol, but about four years ago they were removed to allow for additional committee rooms, and placed in Winder Building, where they now are; although a part of this office, they are separated therefrom and require the continual care and attention of an experienced clerk familiar with their details.

These records are constantly examined by attorneys and others interested in lands in Washington and the person in charge of them is frequently required to produce them in courts; to index them properly, to be able to turn at once to the details of any question raised, requires familiarity with every paper. This duty has for the last few years been intrusted to the only draughtsman allowed this office, and during the past six months more than half of his time has been actually employed on this duty.

I earnestly recommend that this appropriation be made in order that the draughtsman may be permitted to attend to the necessary and legitimate duties of his office.

Third. For one telegraph line-man, $1,000. Under the head of "telegraph connecting the Capitol with Departments" will be found a full description of the telegraph system under charge of this office; it includes about 8 miles of overhead wire and 2.6 miles of underground cable; there are seventeen offices connected with these lines, the main battery being at this office; the line-man is constantly engaged in the care of the main and local batteries and such necessary repairs and extensions as a system of wires of this kind requires; he is industrious, efficient and capable, and has won the confidence of all with whom he has come in contact by faithful attention to his duties.

Fourth. For overseers, foremen, draughtsmen, gardeners, mechanics, and laborers, $30,000.

I have submitted the same estimate as presented last year, being $2,000 in excess of the last appropriation.

The grounds under charge of this office cover an area of 413½ acres, divided into 331 reservations scattered over various sections of the city. Of these reservations 55 are highly improved, 47 partially improved, and 229, covering an area of about 71½ acres, remain entirely unimproved.

Each year we improve from three to five of those heretofore untouched, thus adding to the beauty of the city and the welfare of the neighborhood in which the reservations are situated. These new improvements are distributed throughout different sections of the city, and are only made where private enterprise has improved property in the vicinity. Each improved reservation adds that much to the expense of the care of the public grounds, the mowing of grass, care and construction of paths, care of trees and shrubs, etc.

It is earnestly recommended that this appropriation may be made in order that the beauty of these numerous parks, so ornamental to the nation's capital, may be maintained.

Fifth. One day watchman at Lafayette Square, $720; one day watchman at Franklin Square, $720.

These men are earnest, faithful, and efficient; they have charge of the two handsomest parks in the city; they are busy every day of the year, and during the season of active operations are on duty from 8 a. m. till 8 p. m.

Sixth. One day watchman for Marion Square, Folger Square, and adjacent reservations, $660.

These two reservations are highly improved, the one containing an area of about 1 acre, the other about 2 acres; in addition to these there are several smaller improved reservations in the vicinity; a watchman is very necessary in this locality, the nearest one being at Lincoln Square, a distance of half a mile, where his entire time is required.

Seventh. For improvement of grounds north of the Executive Mansion, $2,500. It is proposed to remove the old broken asphalt walks now in very bad condition and to replace them with new materials and to resurface the old roadway leading from the main road to the greenhouses; the work will consist of constructing about 900 square yards of paths and resurfacing about 1,000 square yards of roadway.

Eighth. For improvement, care, and maintenance of grounds south of the Executive Mansion, $6,000. These funds will be devoted to completing necessary drainage due to raising Potomac Flats, to grading and im-

proving the northwest section of the reservation covering an area of about 2 acres, recently occupied as a storage ground in connection with the construction of the War, State and Navy Building, to resurfacing roads and paths and constructing additional walks, and to care of lawns, planting trees and shrubs, etc.

Ninth. For care and improvement of Monument Grounds, $5,000. In view of the work of filling around the Monument and of the raising of the Potomac Flats, it will be necessary to make improvements in the drainage system and rearrange the roads, paths, lawns, etc., in this reservation; the amount requested will be applied to these purposes.

Tenth. For laying asphalt walks in various reservations, $10,000. It is proposed to replace with first-class asphalt paths the gravel paths in Washington Circle, Franklin Square, Mount Vernon Square, Executive Mansion Grounds (south side), Lincoln Square, Stanton Square, Folger Square, Marion Square, Henry and Seaton Parks, and to renew those in Farragut Square and Iowa Circle. In the late fall, winter, and early spring these walks are muddy, and pedestrians seek the lawns, which are thus destroyed by trespassers. The amount of these paths which it is proposed to lay this year is about 6,000 square yards. Each autumn it becomes necessary to put down plank walks, which must again be removed in the spring. If asphalt walks are laid the annual expense incident to plank walks will be avoided.

Eleventh. For improvement, care, and maintenance of various reservations, $20,000.

The funds required under this head are for the purchase of materials for, and the care of, the improved parks and for the improvement of as many as possible of the 229 unimproved reservations; each year from three to five are added to the list of improved reservations, and if the funds now requested become available eight or ten can be added during the fiscal year ending June 30, 1889; as reservations are thus improved the expense of the care of the whole is slightly increased, for the improvements must be maintained.

Twelfth. For the improvement, care, and maintenance of Smithsonian Grounds, including the construction of asphalt roads and paths, $12,000.

This reservation, covering an area of over 58 acres, is the largest and one of the handsomest in the city, and has within its limits the Smithsonian Building, the National Museum, and the new Army Medical Museum.

The roads and paths, with one or two exceptions, are of gravel and become dusty in summer and muddy in winter; a first-class asphalt road pavement is now in course of construction in front of the Smithsonian Building, running from Seventh to Twelfth street, a distance of about 1,700 feet and covering an area of about 7,500 square yards; 2,700 square yards has been completed, 2,500 square yards will be laid during the season of 1887, and it is hoped that a sufficient appropriation will be made to complete the road during the season of 1888. With the appropriation now requested it is proposed to lay about 2,300 square yards of roadway pavement, about 1,000 square yards of asphalt paths leading through the park to the Museum, and to maintain in good condition the gravel roads and paths, gutters, lawns, trees, shrubs, and drainage of this handsome park.

Thirteenth. For improvement, care, and maintenance of Henry (Armory) and Seaton parks, $5,000. These reservations, extending from Seventh street to the Botanical Gardens, cover an area of 34 acres, with road and walk surfaces of over 10,000 square yards. They are in an advanced state of improvement. Their beauty has been marred by the de-

pot and tracks of the Baltimore and Potomac Railroad. A mound has been constructed around the depot, upon which it is intended to plant trees and shrubs, so that in time the depot will be hidden partially from view. The materials for this mound have thus far been obtained free of expense to the United States, and it is now proposed to grade the mound and to seed and plant it. The funds requested are needed for this purpose, and for the care of roads, lawns, gutters, etc., and laying out additional paths.

Fourteenth. For improvement, care, and maintenance of Judiciary Square, including grounds around the new Pension Building, $10,000.

This square contains an area of 20 acres, and includes within its limits the court-house and the new Pension Building. It is crowded daily with persons having business in these buildings. The appropriation now requested will be used, if granted, for completing the improvements around the Pension Building, constructing asphalt walks leading to the court-house, and in the general care of this large reservation.

Fifteenth. For constructing an ornamental structure of masonry and iron over the springs in Franklin Square, $2,000.

The recommendation made in my last annual report is renewed. These valuable springs should be made available for the use of the residents in the vicinity and the public in general. It is proposed to make the necessary excavation, to construct a grotto that will be an ornament to the park, and to connect the steps leading down to the spring with the main walks by asphalt paths.

Sixteenth. For lodges for park watchmen in Stanton, Mount Vernon, Iowa, Du Pont, Thomas, McPherson, and Folger reservations, at $500 each, $3,500.

The watchmen in these reservations are exposed to the inclemency of the weather at all seasons of the year. Rain or shine, hot or cold, night or day, year in and out, they must be at their stations, and take shelter, when necessary, either under a tree or in such dwelling or store as will offer its hospitality.

The dictates of humanity call for this appropriation.

Seventeenth. For improvement of reservation No. 101, $3,000.

This reservation is now occupied by the Baltimore and Potomac Railroad Company, the tracks of which run through it. These tracks should be removed, and the reservation used for the purpose for which it was originally intended—a public park, for the adornment of the city.

Eighteenth. For supplying and keeping supplied the vases in the new Pension Building with suitable plants and shrubs, $1,000.

The joint resolution of Congress approved March 29, 1886, requires that the seventy-six large vases on the upper corridor of the new Pension building shall be filled and kept filled with suitable plants and shrubs. This estimate is submitted in order that I may be able to comply with the terms of the law.

Nineteenth. For continuing the carriage roadway on the prolongation of Sixteenth street through Lafayette square to Pennsylvania avenue, $4,000.

Sixteenth street now ends at H streett. It is thought that it would be well to extend it by an asphalt park road through Lafayette Square to Pennsylvania avenue.

Twentieth. For care, repair, and refurnishing the Executive Mansion, $16,000.

This old building needs continual repairs and repainting to maintain it in a neat and habitable condition. Much of the furniture is old and needs renewing, while new carpets are required in many of the rooms.

During the past ten years the appropriations for this purpose have been as follows; 1878, $20,000; 1879, $25,000; 1880, $25,000; 1881, $20,000; 1882, $50,000; 1883, $40,000; 1884, $28,000; 1885, $22,500; 1886, $16,000, including $4,000 for new roof; 1887, $16,000; 1888, $16,000. It will be observed that since July 1, 1885, the appropriations have been much less than previous to that time.

It is earnestly recommended that this appropriation be made, as it is absolutely necessary in order to maintain in a neat and habitable condition the mansion provided for the office and the residence of the Chief Executive of the nation.

Twenty-first. For care and necessary repair of greenhouses, $5,000.

The sum appropriated for this purpose during the past four years has been annually only $4,000, while in previous years it was $5,500. The greenhouses need continual repair; they have not been extended in any way during the past three years and require the constant supervision of three experienced gardeners, while the assistance of laborers is necessary from time to time.

Twenty-second.—For renewing the entire superstructure of one greenhouse connected with the Executive Mansion and grounds, $1,500.

The greenhouses were constructed in years past under appropriations made by Congress. The superstructure of three of them is in wretched condition; one will be renewed this season, and this appropriation is asked so that another can be built next season. The timber is so badly decayed that the superstructure is liable to fall during a heavy storm.

Twenty-third.—For erecting a tower in the ellipse south of the Executive Mansion, from the top of which shall be shown an electric light from six arc lamps of 2,000 candle-power each, $750.

For electric lights for 365 nights from six arc lamps of 2,000 candle-power, each, at $4.20 per night, $1,533.

The grounds south of the Executive Mansion, now highly improved, are without lights. It is believed that the electric lights mentioned above will shed a soft mellow light over the entire grounds, including those within the fence on the south side of the White House. The appropriation for the construction of this tower and for the electric lights throughout the year is earnestly recommended.

Twenty-fourth. For furnishing a full supply of water for all purposes to the Executive Mansion by connecting the mansion by a 12-inch main with the 36-inch main on L street, $5,300.

The mansion is now supplied by means of a 4 inch pipe connected with the 12-inch main on Pennsylvania avenue. The pressure of water entering the building is not sufficient for ordinary purposes, and it is necessary to use pumping-engines to fill the tanks that run the elevator and supply the hot-water boilers, the bath-tubs, closets, etc. It is believed that by the plan now proposed a full and complete supply of water will be furnished the mansion at all times.

During the past year, owing to accidents to the pumping-engines, the elevator could not be run on several occasions, and once, when the gas-engine that is used to fill the tank that supplies the kitchen boilers, the bath-rooms, closets, etc., got out of order, the tank became empty, and the usual trouble incident to a lack of water followed.

Twenty-fifth.—For replacing the overhead wires between the Capitol and the Departments with a duplicate underground six-wire cable, $8,500.

This subject has been discussed in the preceding pages of this report. The growth of the trees on the sidewalks renders it absolutely nec-

essary, in order to maintain telegraphic communication over these wires, either to erect at once taller poles at a cost of about $1,600, or to lay an under-gound cable at a cost of $8,500. The former plan is but a temporary expedient, as in time the overhead-wire system through cities must be abolished. The under-ground cable is far preferable, and favorable action upon this estimate is earnestly recommended.

Financial statement for fiscal year ending June 30, 1887.

Title of appropriation.	Available at the beginning of the fiscal year.	Expended during fiscal year.	Unexpended balance to be covered into the Treasury.
Improvement and care of public grounds, 1887	$64,200.00	$63,922.05	$277.95
Repairs, fuel, etc., Executive Mansion, 1887	29,000.00	28,996.98	3.02
Repairs, fuel, etc., Executive Mansion, 1885 (deficiency act, approved August 4, 1886)	135.50	135.50	....
Lighting, etc., Executive Mansion, etc., 1887	14,000.00	13,629.47	370.53
Repairs to water-pipes and fire-plugs, 1887	2,500.00	1,858.23	641.77
Telegraph to connect the Capitol with the Departments and the Government Printing Office, 1887	1,250.00	1,249.46	.54
Contingent expenses, public buildings and grounds under Chief of Engineers, 1887	500.00	499.99	.01
Rent of office public buildings and grounds under Chief of Engineers, 1887	900.00	900.00	....
Salaries of employés of public buildings and grounds under Chief of Engineers, 1887	45,507.90	45,449.36	58.54
Removal of statue of General John A. Rawlins (act May 17, 1886)	500.00	500.00	....

There is submitted herewith a description of the various reservations comprising the public grounds under charge of this office, together with a map thereof.

It gives me pleasure, in conclusion, to again express my appreciation of the faithful and efficient manner in which Mr. George H. Brown, the public gardener, and Mr. E. F. Concklin, the overseer and chief clerk, have performed the various and important duties committed to their charge.

I am, general, very respectfully, your obedient servant,

JOHN M. WILSON,
Lieut. Col. of Engineers, Colonel U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

SYNOPSIS OF UNITED STATES PUBLIC RESERVATIONS IN THE CITY OF WASHINGTON, DISTRICT OF COLUMBIA, TO ACCOMPANY ANNUAL REPORT UPON PUBLIC BUILDINGS AND GROUNDS FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

Number, area, location, and description of the Government parks and reservations comprising the public grounds of Washington, D. C., under the control of the Chief of Engineers, U. S. Army.

Description.	Number.	Area.
		Acres.
Total number of reservations	331	413.52
Reservations highly improved	55	231.28
Reservations partially improved	47	110.55
Reservations unimproved	229	71.69

No. 1. *President's Park* (formerly *White Lot;* area, 82 acres 9,683 square feet; highly improved):

Between Fifteenth and Seventeenth streets west and B street and Pennsylvania avenue north. The Executive Mansion, United States Treasury, State, War and Navy Department buildings are located on the northern portion of this reservation, in separate inclosures, surrounded by iron railings and flag-stone pavements. These inclosed spaces are laid out in walks and lawn surfaces, are well lighted and interspersed with ornamental evergreen and deciduous trees and shrubs, and parterres for summer planting of exotic flowering and foliaged plants. The southern portion of the park, except a limited area still occupied by the stone-yard and work-shops, of the State, War and Navy Building, has been improved; gravel roads and walks have been laid out for public travel, the lawn surfaces have been arranged, and the planting of the ground with natural groups of ornamental evergreen and deciduous trees and shrubs has been nearly completed. No arrangements for lighting these grounds have yet been made. There are two fountains, one on the north front and the other on the south front of the Executive Mansion.

No. 2. *Washington Park* (formerly the *Monument Grounds;* area, 78 acres 22,678 square feet; but partially improved):

Between Fourteenth street west and the Potomac River and B street north and B street south. This area includes the nursery grounds, under control of this office, and the lakes on the northwestern portion of the grounds, under the control of the U. S. Fish Commission.

The Washington Monument is located near the river-front in the western portion of the park. The grounds around the monument are being raised and will eventually be well improved. A portion of the main roads of the park has been laid out for public travel, the lawn surfaces graded and planted in part with evergreen and deciduous trees. The nursery and propagating garden of the public grounds is in an advanced stage of improvement and comprises an area of about 7 acres. The carp ponds, lakes, and grounds, under control of the Fish Commission, comprise an area of about 20 acres.

No. 3. *Smithsonian Park* (area, 58 acres 1,260 square feet; highly improved):

Between Seventh and Twelfth streets west and from B street north to B street south. The Smithsonian Institution, the National Museum, and the Army Medical Museum and Library are located in this park. These grounds are in an advanced stage of improvement; inclosed in part with a post and chain fence, and in part with a substantial iron railing; gas-lamps around and on main lines of travel through the park; gravel roads and walks in good condition, broad lawn surfaces planted with a choice selection of evergreen and deciduous trees and shrubs. The statue of the late Professor Henry, by W. W. Story, is located at the intersection of the main roadways northwest of the Institute building in these grounds. The construction of asphalt pavements has been commenced during the present season. Two drinking fountains and a watchman's lodge are located in this park.

No. 4. *Henry Park* (formerly *Armory Park*; area, 14 acres 37,830 square feet; highly improved):

Between Sixth and Seventh streets west and B street north and B street south. The Baltimore and Potomac Railroad Passenger Depot and the Armory Building (now used for storage purposes by the U. S. Fish Commission) are located in this park. These grounds are now in an advanced stage of improvement; inclosed with post and chain fence in part, and in part with a substantial iron railing; gas-lamps around and on main lines of travel through the park; gravel roads and walks in good condition, lawn surfaces partly planted with ornamental evergreen and deciduous trees and shrubs. The main roadway of this park is continued over Sixth street on a substantial iron bridge, constructed by the Baltimore and Potomac Railroad Company. A large mound is being constructed, which will be planted with evergreen and deciduous trees and shrubs to screen the depot from the park.

No. 5. *Seaton Park* (area, 12 acres 21,902 square feet; highly improved):

Between Four-and-a-half streets west and Maine and Missouri avenues north. These grounds are in an advanced stage of improvement, inclosed with post and chain fence, gas-lamps around and on main lines of travel through the park, gravel roads and walks in good condition, lawn surfaces partly planted with ornamental evergreen and deciduous trees and shrubs.

No. 6. *Seaton Park* continued (area, 6 acres 19,440 square feet; highly improved):
Between Third and Four-and-a-half streets west and Maine and Missouri avenues. These grounds are in an advanced stage of improvement, inclosed with post and chain fence, gas-lamps around and on main lines of travel through the park, gravel road and walks in good condition, lawn surfaces partly planted with ornamental evergreen and deciduous trees and shrubs. There are two drinking fountains in this park.

No. 7. *Judiciary Park* (area, 19 acres 35,712 square feet; highly improved):
Between Fourth and Fifth streets west and Indiana and Louisiana avenues and G street north. The City Hall and new Pension Office buildings are located in this park. These grounds are improved in part, inclosed with post and chain fence, gas-lamps around and on main lines of travel through the park; watchman's lodge with public conveniences, two drinking fountains and one jet fountain are in this park; general roads and walks in good condition, lawn surfaces partly planted with ornamental evergreen and deciduous trees and shrubs and flower-beds in front of watchman's lodge. The north section of the park around the Pension Building is now being improved.

No. 8. *Mount Vernon Park* (area, 2 acres 27,673 square feet; highly improved):
Between Seventh and Ninth streets northwest, at the intersection of Massachusetts and New York avenues. This park is improved and planted with ornamental evergreen and deciduous trees and shrubs; inclosed with post and chain fence; gas-lamps around and through the park; two drinking fountains and one ornamental iron jet fountain in the center of the park; gravel and asphalt walks on direct lines of travel through the park and lawn surfaces, interspersed with flower beds for summer planting of exotic flowering and foliaged plants.

No. 9. *Franklin Park* (area, 4 acres 28,590 square feet; highly improved):
Between Thirteenth and Fourteenth streets west and I and K streets north. This park is inclosed with a substantial iron railing; gas-lamps around and through the park; two drinking fountains, and a watchman's lodge with public conveniences, and a fountain in the center of the park with a set of French jets and ornamental polished Aberdeen granite coping; lawn surfaces planted with choice ornamental evergreen and deciduous trees and shrubs, and interspersed with beds and borders for summer planting of decorative flowering and foliaged plants; asphalt and gravel walks on lines of travel through the park.

No. 10. *Lafayette Park* (area, 6 acres 41,444 square feet; highly improved):
Between Pennsylvania avenue and H street north, and Fifteen-and-a-half and Sixteen-and-a-half streets west. This park, from its prominent situation opposite the main front of the Executive Mansion, was one of the first city parks elaborately improved and planted, and contains a choice collection of evergreen and deciduous trees and shrubs, including many fine specimens of rare species not generally found north of Washington; inclosed with a heavy ornamental iron railing; gas-lamps around and through the park; two drinking fountains; lawn surfaces planted chiefly on margins of walks, and interspersed with flower beds and borders for summer planting of exotic flowering and foliaged plants. Two massive antique bronze vases of elaborate design on granite pedestals grace the park at intersections of walks near the eastern and western entrances. The equestrian statue of General Jackson, by Clark Mills, on a white marble pedestal, surrounded by four field pieces of artillery (captured by General Jackson), occupies the center of the park; gravel and asphalt walks are in good condition, and a watchman's lodge, with necessary public conveniences, is located in this park.

No. 11. *McPherson Park* (area, 1 acre 29,446 square feet; highly improved):
Between I and K streets north, at the southeastern terminus of and intersection of Vermont avenue and Fifteenth street west. This park is the site of the equestrian statue of General McPherson, by Louis T. Rebisso. Lawn surfaces are planted mainly with deciduous trees and shrubs; asphalt walks are laid out on diagonal lines; four large iron vases are placed on the lawns and planted with suitable summer decorative plants; there are gas-lamps around and through the park, and a drinking fountain placed at intersection of walks near the center; the park is inclosed with post and chain fence.

No. 12. *Farragut Park* (area, 1 acre 26,216 square feet; highly improved):
Between I and K streets north and terminus and intersection of Connecticut avenue and Seventeenth street west. The bronze statue of Admiral Farragut, by Mrs. Vinnie Ream Hoxie, is located in the center of this park; lawn surfaces are planted with evergreen and deciduous trees and

No. 12. *Farragut Park*—Continued.
shrubs, and interspersed with flower-beds, etc.; asphalt walks are laid out in diagonal lines, and a drinking fountain placed at intersection of the walks; gas-lamps are around and through the park; inclosed with post and chain fence.

No. 13. *Rawlins Park* (area, 1 acre 30,218 square feet; highly improved):
Between Eighteenth and Nineteenth streets west and at the intersection of New York avenue and E street north. This park is inclosed with post and chain fence; improved and planted with evergreen and deciduous trees and shrubs; lawn surfaces planted chiefly on margins of walks; two rustic fountains are located near the eastern and western entrances; asphalt walks are laid out on direct lines of travel; gas-lamps are around and through the park.

No. 14. *Lincoln Park* (area, 6 acres 13,404 square feet; highly improved):
Between Eleventh and Thirteenth streets east and at the intersection of Kentucky, Tennessee, North Carolina, and Massachusetts avenues. The bronze statue of "The Emancipation," by Thomas Ball, is located in this park. These grounds are in an advanced stage of improvement; inclosed with post and chain fence; gas-lamps around the park and on lines of walks through it; lawn surfaces planted with choice evergreen and deciduous trees and shrubs, interspersed with flower-beds, etc.; gravel walks on needed lines of travel are in good condition. There are two drinking fountains and a watchman's lodge, with public conveniences, in the park. Two ornamental fountains (spray jets and Portland cement stone copings and basins) are placed at northern and southern entrances to this park.

No. 15. *Stanton Park* (area, 3 acres 2,145 square feet; highly improved):
Between Fourth and Sixth streets east and at the intersection of Massachusetts and Maryland avenues. The bronze equestrian statue of General Greene, by Henry K. Brown, is located here. The park is inclosed with post and chain fence; gas-lamps are around and through the park; lawn surfaces planted with choice evergreen and deciduous trees and shrubs; gravel walks on direct lines of travel, flower-beds are laid out at the base of the pedestal of the statue for summer planting of decorative flowering plants; two ornamental rustic fountains are located at intersection of walks, and there are two drinking fountains in the park.

No. 16. Folger Park (area, 1 acre 39,654 square feet; highly improved):
Between Second and Third streets east and at the intersection of North Carolina avenue and D street south. This park is on the north front of Providence Hospital and is inclosed with post and chain fence; gas-lamps around and through the park; gravel walks on direct lines of travel, and the lawn surfaces are partly planted with deciduous trees; there is also a granite fountain in the center of the park.

No. 17. *Garfield Park* (area, 23 acres 42,691 square feet; partially improved):
Between South Capitol and Third streets east and at the intersection of New Jersey and Virginia avenues. The work of laying out this park and grading it in accordance with the plans prepared for its improvement is now in progress, and will be advanced toward completion as rapidly as available appropriations will permit. The eastern section is nearly completed.

No. 18. *Marion Park* (area, 1 acre 26,840 square feet; highly improved):
Between Fourth and Sixth streets east, at the intersection of South Carolina avenue and E street south. These grounds have been recently highly improved; gas-lamps placed around and through the park; gravel walks constructed on direct lines of travel, and lawn surfaces planted with evergreen and deciduous trees and shrubs. There is a handsome large Hilton iron vase in this park.

No. 19. Rectangle (area, 1 acre 42,648 square feet; unimproved):
Between Tenth and Twelfth streets west, and the intersection of Ohio and Louisiana avenues.

No. 20. Triangle (area, 3,502 square feet; partially improved):
At the intersection of Pennsylvania avenue and M street northwest and between 28th and 29th streets. Graded, and fountain in the center of the triangle; there is also a handsome iron vase in the park.

No. 21. Triangle (area, 2,275 square feet; highly improved):
Between Twenty-fifth and Twenty-sixth streets west, at the intersection of Pennsylvania avenue and L street north. Inclosed with a light wrought iron railing; improved and planted mainly with flowering dwarf trees and shrubs.

No. 22. Triangle (area, 4,908 square feet; partially improved):
Between Twenty-fourth and Twenty-fifth streets west and at the intersection of Pennsylvania avenue and L street north. Inclosed with a post and chain fence; graded but not planted.

No. 23. Trapezoid (area, 3,150 square feet; partially improved):
Between Twenty-third and Twenty-fourth streets west and at the intersection of Pennsylvania avenue and K street north. Inclosed with post and chain fence, and lawn surface graded.

No. 24. *Washington Circle* (area, 1 acre 36,865 square feet; highly improved):
At the intersection of Pennsylvania and New Hampshire avenues and K and Twenty-third streets northwest. These grounds are in a highly improved condition and are encircled by a granite curbing; gravel walks on convenient lines of travel are in good condition; gas-lamps around and through the park; lawn surfaces planted with choice evergreen and deciduous trees and shrubs and interspersed with flower-beds for summer decorative planting of flowering and foliaged plants; there is a watchman's lodge in this park and two drinking fountains. This is the site of the equestrian statue of General Washington, by Clark Mills.

No. 25. Trapezoid (area, 3,159 square feet; partially improved):
Between Twenty-second and Twenty-third streets west and at the intersection of Pennsylvania avenue and K street north. Inclosed with a post and chain fence, lawn surface graded.

No. 26. Trapezoid (area, 18,156 square feet; highly improved):
Between Twentieth and Twenty-first streets west and at the intersection of Pennsylvania avenue and I street north. Inclosed with post and chain fence, improved and planted with choice evergreen and deciduous trees and shrubs; gas-lamps around park; drinking fountain at the eastern end, and a rose jet fountain in the center of the park; gravel walks are laid diagonally through the park.

No. 27. Trapezoid (area, 11,893 square feet; highly improved):
Between Twentieth and Twenty-first streets west and at the intersection of Pennsylvania avenue and I street north. Inclosed with heavy cast-iron railing, lawn surface thickly planted with deciduous trees.

No. 28. Triangle (area, 18,511 square feet; highly improved):
Between Eighteenth and Nineteenth streets west and at the intersection of Pennsylvania avenue and H street north. Inclosed with a post and chain fence; planted with deciduous and evergreen trees and shrubs; a large Warwick iron vase, planted in summer with suitable decorative plants, is placed at the eastern entrance to the park; there is a rustic fountain with rose jet in the center; gas-lamps around and concrete walks through the park.

No. 29. Triangle (area, 14,749 square feet; highly improved):
Between Eighteenth and Nineteenth streets west and at the intersection of Pennsylvania avenue and H street north. Inclosed with post and chain fence; planted with deciduous and evergreen trees and shrubs; gas-lamps around, and gravel walks through the park; a large Warwick iron vase and a center flower bed for summer decorative planting, are in this park.

No. 30. Trapezoid (area, 18,482 square feet; partially improved):
Between Thirteen-and-a-half and Fourteenth streets west and at the intersection of Pennsylvania avenue and E street north. Inclosed with a heavy cast-iron railing, and planted with deciduous trees.

No. 31. Triangle (area, 21,371 square feet; partially improved):
Between Thirteenth and Thirteen-and-a-half streets west and Pennsylvania avenue and E street north. Inclosed with heavy cast-iron railing; lawn planted with a few deciduous trees of large growth.

No. 32. Trapezoid (area, 7,678 square feet; highly improved):
Between Ninth and Tenth streets west and at the intersection of Pennsylvania avenue and Ninth street. Inclosed with post and pipe rail fence; lawn planted with deciduous trees and shrubs; flower-beds for summer planting; ornamental cast-iron fountain in the center: Portland-cement pavement around and through, and gas lamps around the park.

No. 33. Triangle (area, 5,529 square feet; highly improved):
Between Eighth and Ninth streets west and at the intersection of Pennsylvania and Louisiana avenues. The bronze statue of General John A. Rawlins, by A. Bailly, is now located in this park. Inclosed with post and pipe-rail fence; lawn planted with deciduous trees of large growth, and asphalt walks through park.

No. 34. Trapezoid (area, 15,525 square feet; partially improved):
Between Seventh and Eighth streets west and at the intersection of Pennsylvania and Lousiana avenues. Inclosed with post and chain fence; lawn planted with deciduous trees of large growth, but otherwise unimproved.

No. 35. Triangle (area, 8,544 square feet):
Transferred for use as site for Congressional Library.

No. 36. Triangle (area, 5,994 square feet):
Transferred for use as site for Congressional Library.

No. 37. Triangle (area, 4,621 square feet; partially improved):
Between Second and Third streets east and at the intersection of Pennsylvania avenue and B street south. Inclosed with post and chain fence; lawn surface arranged and a flower-bed in the center.

No. 38. Triangle (area, 13,360 square feet; partially improved):
Between Fourth and Fifth streets east and at the intersection of Pennsylvania and North Carolina avenues. Inclosed with post and pipe rail fence; lawn surface arranged with a flower-bed in the center; planted in part with a few shrubs and trees and water introduced.

No. 39. Trapezoid (area, 11,216 square feet; partially improved):
Between Fourth and Fifth streets east and at the intersection of Pennsylvania and North Carolina avenues. Inclosed with post and pipe rail fence; lawn surface arranged with a flower-bed in the center and planted in part.

No. 40. Triangle (area 3, 904 square feet; highly improved):
Between Fourth and Fifth streets east and at the intersection of Pennsylvania and North Carolina avenues. Inclosed with post and pipe rail fence; lawn surface arranged with a flower-bed in the center and planted in part, and water introduced.

No. 41. Trapezoid area, 3,613 square feet; partially improved):
Between Fifth and Sixth streets east and at the intersection of Pennsylvania and North Carolina avenues. Inclosed with a post and pipe rail fence; planted in part; lawn surface arranged with a flower-bed in the center and a large ornamental flower-vase in the center of the flower-bed.

No. 42. Triangle (area, 10,899 square feet; highly improved):
Between Fifth and Sixth streets east and at the intersection of Pennsylvania and North Carolina avenues. Inclosed with a post and pipe rail fence; lawn surface arranged with a flower-bed in the center; planted in part and water introduced.

No. 43. Triangle (area, 13,561 square feet; partially improved):
Between Fifth and Sixth streets east and at the intersection of Pennsylvania and North Carolina avenues. Inclosed with a post and pipe rail fence; lawn surface arranged with a flower-bed in the center; a few shrubs planted and water introduced.

No. 44. Triangle (area, 15,344 square feet; partially improved):
Between Seventh and Eighth streets east and at the intersection of Pennsylvania and South Carolina avenues. Inclosed with a post and pipe-rail fence; lawn surface arranged with a flower-bed in center, a few shrubs planted, and water introduced.

No. 45. Triangle (area, 13,523 square feet; partially improved):
Between Seventh and Eighth streets east and at the intersection of Pennsylvania and South Carolina avenues and D street south. Inclosed with post and pipe rail fence; lawn surface arranged with a flower-bed in the center, and water introduced.

No. 46. Triangle (area, 1,680 square feet; partially improved):
Between Seventh and Eighth streets east and at the intersection of Pennsylvania avenue and D street south. Inclosed with post and pipe rail fence; lawn surface arranged.

No. 47. Triangle (area, 852 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of Pennsylvania and South Carolina avenues and D street south.

No. 48. Triangle (area, 13,523 square feet; partially improved):
Between Eighth and Ninth streets east and at the intersection of Pennsylvania avenue and D street south; lawn surface arranged.

No. 49. Triangle (area, 15,344 square feet; partially improved):
Between Eighth and Ninth streets east and at the intersection of Pennsylvania and South Carolina avenues. Lawn surface arranged, sown with grass seed, and water introduced; inclosed with a post and chain fence, and a flower-bed planted.

No. 50. Triangle (area, 4,000 square feet; partially improved):
Between Tenth and Eleventh streets east and at the intersection of Pennsylvania avenue and E street south. Lawn surface arranged, sown with grass seed, and water introduced.

No. 51. Triangle (area, 14,942 square feet; unimproved):
Between Eleventh and Twelfth streets east and at the intersection of Pennsylvania avenue and E street south.

No. 52. Trapezoid (area, 10,962 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of Pennsylvania avenue and G street south.

No. 53. Triangle (area, 6,800 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Pennsylvania avenue and G street south.

No. 54. Rectangle (area, 1 acre, 4,788 square feet; unimproved):
Between Thirteenth and Fifteenth streets east and at the intersection of Pennsylvania and Georgia avenues south.

No. 55. Circle (area, 5 acres 21,514 square feet; unimproved):
At the junction of Pennsylvania and Kentucky avenues and L and K treets south, between Seventeenth and Water streets. A portion of this circle is below grade and covered with water at high tide.

No. 56. Triangle (area, 2,435 square feet; partially improved):
Between Twenty-first and Twenty-second streets west and at the intersection of Massachusetts avenue and Q street north. Lawn surface arranged and sodded.

No. 57. Triangle (area, 4,278 square feet; highly improved):
Between Twenty-first and Twenty-second streets west and at the intersection of Massachusetts avenue and Q street north. Inclosed with post and chain fence; planted with deciduous trees and shrubs; a large Warwick iron vase placed in the center and water introduced.

No. 58. Triangle (area, 8,673 square feet; partially improved):
Between Nineteenth and Twentieth streets west and at the intersection of Massachusetts avenue and P street north. Inclosed with post and chain fence; graded, sodded, an ornamental fountain placed in the center, and water introduced.

No. 59. *Du Pont Circle* (area, 2 acres 14,667 square feet; highly improved):
Between Eighteenth and Twentieth streets west and at the intersection of Massachusetts, Connecticut, and New Hampshire avenues. The pedestal and statue of Rear-Admiral Du Pont, by Mr. Launt Thompson, is located in the center of this park. These grounds have been improved, and planted with a choice collection of dwarf ornamental flowering trees and shrubs; a number of evergreen and deciduous trees of large growth have also been planted. Inclosed with post and chain fence; gas lamps around and through the circle; two drinking fountains at intersections of walks; lawn surface interspersed with flower-beds; water introduced, and asphalt walks laid on direct lines of travel through the circle.

No. 59½. Trapezoid (area, 2,200 square feet; unimproved):
Between Eighteenth and Nineteenth streets west and at the intersection of Massachusetts avenue and P street north.

No. 60. Trapezoid (area, 13,964 square feet; highly improved);
Between Sixteenth and Seventeenth streets west and at the intersection of Massachusetts and Rhode Island avenues. Inclosed with post and chain fence; lawn surface, planted mainly with specimen dwarf trees and assorted varieties of flowering shrubs; flower-bed in the center, and water introduced.

No. 61. *Scott Circle* (area, 11,309 square feet; highly improved):
At the intersection of Massachusetts and Rhode Island avenues and Sixteenth street west. This circle is the site of the bronze statue of General Winfield Scott, by Henry K. Brown. Improved and planted; flower-beds laid out on the lawn surface and at the base of the statue; gas-lamps and flag-stone pavement around the circle, and water introduced.

No. 62. Trapezoid (area, 13,964 square feet; highly improved).
Between Fifteenth and Sixteenth streets west and at the intersection of Massachusetts and Rhode Island avenues north. Inclosed with post and chain fence; lawn surface, planted with dwarf ornamental evergreen and deciduous trees and flowering shrubs; flower-bed in the center; gas-lamps and stone pavement around the park, and water introduced.

No. 63. Trapezoid (area, 3,376 square feet; partially improved):
Between Fourteenth and Fifteenth streets west and at the intersection of Massachusetts avenue and M street north. Inclosed with a light iron railing; improved and partly planted.

No. 64. *Thomas Circle* (area, 27,347 square feet; highly improved):
At intersection of Massachusetts and Vermont avenues and Fourteenth street west. This circle is the site of the bronze equestrian statue of General George H. Thomas, by J. Q. A. Ward. The grounds are improved, flower-beds laid out in the lawn surface, and gas-lamps on the pedestal of the statue and around the circle; a flag-stone pavement also surrounds the circle, and water has been introduced.

No. 65. Trapezoid (area, 3,005 square feet; partially improved):
Between Thirteenth and Fourteenth streets west and at the intersection of Massachusetts avenue and M street north. Inclosed with iron post and rail fence, graded, and sodded.

No. 66. Trapezoid (area, 16,073 square feet; highly improved):
Between Eleventh and Twelfth streets west and at the intersection of Massachusetts avenue and L street north. Inclosed with post and chain fence; planted with evergreen and deciduous trees and shrubs, mainly of dwarf growth; asphalt walks are laid on direct lines of travel; flower-beds laid out at intersection of walks; gas-lamps are around the park and a drinking fountain located at its eastern end; two large ornamental flower-vases are placed in suitable positions, and water has been introduced.

No. 67. Trapezoid (area, 18,412 square feet; highly improved):
Between Tenth and Eleventh streets west and at the intersection of Massachusetts avenue and L street north. Inclosed and improved in a similar manner to No. 66 (the reservation before described) and situated just opposite.

No. 68. Trapezoid (area, 7,081 square feet; partially improved):
Between Ninth and Tenth streets west and at the intersection of Massachusetts and New York avenues and K street north. Inclosed with iron railings and planted with flowering shrubs.

No. 69. Trapezoid (area, 6,042 square feet; highly improved):
At the intersection of Massachusetts avenue, Seventh street west, and K street north. Inclosed with post and chain fence; flower-bed in the center of lawn surface, and water introduced; gas-lamps and flag-stone pavement around the park.

No. 70. Trapezoid (area, 16,895 square feet; highly improved):
Between Fifth and Sixth streets west and at the intersection of Massachusetts avenue and I street north. Inclosed with a light wrought-iron railing; planted mainly with low-growing ornamental trees and shrubs; flower-beds laid out, and water introduced.

No. 71. Trapezoid (area, 11,330 square feet; highly improved):
At the intersection of Massachusetts avenue and I street north and Fifth street west. Inclosed with post and chain fence; gravel walks in direct lines of travel; planted mainly with low-growing trees and shrubs, and water introduced.

No. 72. Triangle (area, 5,949 square feet; partially improved):
At the intersection of Massachusetts avenue and H street north and between Third and Fourth streets west. Inclosed with post and pipe-rail fence; graded and sown in grass; otherwise unimproved.

No. 73. Triangle (area, 5,421 square feet; partially improved):
Between Third and Fourth streets west and at the intersection of Massachusetts avenue and H street north. Inclosed with post and pipe-rail fence; graded and sown in grass; otherwise unimproved.

No. 74. Circle (area, 15,394 square feet; partially improved):
Between North Capitol and First streets west and at the intersection of Massachusetts and New Jersey avenues. Graded and in grass only.

No. 75. Triangle (area, 4,725 square feet; unimproved):
Between North Capitol and First streets west and at the intersection of Massachusetts avenue and F street north.

No. 76. Triangle (area, 4,554 square feet; unimproved):
Between North Capitol and First streets east and at the intersection of Massachusetts avenue and F street north.

No. 77. Triangle (area, 1,205 square feet; unimproved):
At the intersection of Massachusetts avenue and Delaware avenue and First street east.

No. 78. Trapezoid (area, 25,240 square feet; highly improved):
At the intersection of Massachusetts and Delaware avenues, First street east and F street north. Inclosed with post and chain fence; has gravel walks, rustic fountain in the middle, gas-lamps around the park, lawns planted with evergreen and deciduous trees and shrubs, and a flower border around fountain.

No. 79. Triangle (area, 4,062 square feet; unimproved):
Between First and Second streets east and at the intersection of Massachusetts avenue and E street north.

No. 80. Triangle (area, 4,418 square feet; unimproved):
Between Second and Third streets east and at the intersection of Massachusetts avenue and D street north.

No. 81. Trapezoid (area, 4,915 square feet; unimproved):
At the intersection of Massachusetts avenue, D street north, and Third street east.

No. 82. Trapezoid (area, 12,070 square feet, partially improved):
Between Sixth and Seventh streets east and at the intersection of Massachusetts avenue and B street north; inclosed with post and chain fence, graded and in grass, and water introduced.

No 83. Trapezoid (area, 7,840 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of Massachusetts avenue and B street north.

No. 84. Trapezoid (area, 7,840 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of Massachusetts avenue and A street north.

No. 85. Triangle (area, 10,042 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Massachusetts avenue and A street south.

No. 86. Trapezoid (area, 8,505 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Massachusetts avenue and A street south.

No. 87. Triangle (area, 10,011 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of Massachusetts and South Carolina avenues and B street south.

No. 88. Triangle (area, 7,654 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and Massachusetts avenue southeast at the intersection with South Carolina avenue.

No. 89. Triangle (area, 18,354 square feet; unimproved):
Between Seventeenth and Eighteenth streets east and at the intersection of Massachusetts avenue and C street south.

No. 90. Triangle (area, 11,178 square feet; unimproved):
Between Eighteenth and Nineteenth streets east and at the intersection of Massachusetts avenue and C street south.

No. 91. Trapezoid (area, 9,426 square feet; unimproved):
Between Twenty-fifth and Twenty-sixth streets west and at the intersection of Viginia and New Hampshire avenues.

No. 92. Triangle (area, 8,640 square feet; unimproved):
Between Twenty-fourth and Twenty-fifth streets west and at the intersection of Virginia avenue and G street north.

No. 93. Triangle (area, 4,897 square feet; unimproved):
Between Twenty-fourth and Twenty-fifth streets west and at the intersection of Virginia avenue and G street north.

No. 94. Triangle (area, 6,164 square feet; unimproved):
Between Twenty-third and Twenty-fourth streets west and at the intersection of Virginia avenue and F street north.

No. 95. Triangle (area, 4,234 square feet; unimproved):
Between Twenty-first and Twenty-second streets west and at the intersection of Virginia avenue and E street north.

No. 96. Triangle (area, 11,096 square feet; unimproved):
Between Twentieth and Twenty-first streets west and at the intersection of Virginia and New York avenues.

No. 97. Triangle (area, 11,467 square feet; unimproved):
Between Twentieth and Twenty-first streets west and at the intersection of Virginia and New York avenues.

No. 98. Triangle (area, 7,250 square feet; unimproved):
Between Seventeenth and Eighteenth streets west and at the intersection of Virginia avenue and B street north.

No. 99. Trapezoid (area, 10,237 square feet; highly improved):
Between Eleventh and Twelfth streets west and at the intersection of Virginia avenue and B street south; inclosed with post and chain fence, planted with evergreen and deciduous trees and shrubs, and water introduced.

No. 100. Trapezoid (area, 8,695 square feet; unimproved):
Between Ninth and Tenth streets west and at the intersection of Virginia avenue and C street north.

No. 101. Rectangle (area, 2 acres 11,376 square feet; unimproved):
Between Seventh and Ninth streets west and at the intersection of Virginia and Maryland avenues, mainly occupied by the Baltimore and Potomac Railway Company, the tracks running diagonally through it.

No. 102. Trapezoid (area, 10,428 square feet; unimproved):
Between Sixth and Seventh streets west and at the intersection of Virginia avenue and C street south.

No. 103. Trapezoid (area, 8,075 square feet; unimproved):
Between Sixth and Seventh streets west and at the intersection of Virginia avenue and D street south.

No. 104. Triangle (area, 4,625 square feet; partially improved):
Between Four-and-a-half and Sixth streets west and at the intersection of Virginia avenue and D street south; inclosed with post and pipe-rail fence, and partly planted (not graded).

No. 105. Triangle (area, 16,775 square feet; unimproved):
Between Four-and-a-half and Sixth streets west and at the intersection of Virginia avenue and D street south.

No. 106. Trapezoid (area, 14,414 square feet; unimproved):
Between Second and Third streets west and at the intersection of Virginia avenue and E street south.

No. 107. Trapezoid (area, 4,032 square feet; unimproved):
Between Half and First streets west and at the intersection of Virginia and Delaware avenues and E streets south.

No. 108. Trapezoid (area, 10,815 square feet; unimproved):
Between Half and First streets west and at the intersection of Virginia avenue and F street south.

No. 109. Triangle (area, 2,580 square feet; unimproved):
Between South Capitol and Half streets west and at the intersection of Virginia avenue and F street south. (The railroad side-track into Marlow's coal-yard passes through the center of this park.)

No. 110. Rhomboid (area, 6,670 square feet; partially improved):
At the intersection of Virginia avenue and South Capitol and G streets south; partly planted, graded, and sown in grass.

No. 111. Quadrilateral (area, 25,955 square feet; partially improved):
Between Virginia avenue and E street south and at the intersection of Virginia avenue and South Capitol street; partly planted, graded, and sown in grass.

No. 112. Quadrilateral (area, 2,755 square feet; partially improved):
At the intersection of Virginia avenue and South Capitol and G street south; graded, sown with grass, and partly planted. (The Baltimore and Potomac Railroad tracks divide this park into two parts.)

No. 113. Trapezoid (area, 15,916 square feet, unimproved):
Between Fourth and Fifth streets east and at the intersection of Virginia avenue and I street south.

No. 114 Triangle (area, 16,183 square feet, unimproved):
Between Sixth and Seventh streets east and at the intersection of Virginia avenue and I street south.

No. 115. Triangle (area, 9,828 square feet; unimproved):
Between Sixth and Seventh streets east and at the intersection of Virginia avenue and K street south.

No. 116. Trapezoid (area, 18,054 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of Virginia avenue and K street south. (A public school-house has been erected on this park.)

No. 117. Rectangle (area, 1 acre 43,321 square feet; unimproved):
Between Ninth and Eleventh streets east and at the intersection of Virginia and Georgia avenues.

No. 118. Trapezoid (area, 29,391 square feet; unimproved):
Between Eleventh and Twelfth streets east and at the intersection of Virginia avenue and L street south.

No. 119. Triangle (area, 7,272 square feet; unimproved):
Between Twelfth and Thirteenth streets and at the intersection of Virginia avenue and M street south.

No. 120. Triangle (area, 15,225 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Virginia avenue and M street south.

No. 121. Triangle (area, 8,816 square feet; unimproved):
Between Twenty-fifth and Twenty-sixth streets west and at the intersection of New Hampshire avenue and G street north.

No. 122. Triangle (area, 1,014 square feet; unimproved):
Between Twenty-fourth and Twenty-fifth streets west and at the intersection of New Hampshire avenue and H street north.

No. 123. Triangle (area, 660 square feet; unimproved):
Between Twenty-fourth and Twenty-fifth streets west and at the intersection of New Hampshire avenue and I street north.

No. 124. Triangle (area, 6,259 square feet; unimproved):
Between Twenty-first and Twenty-second streets west and at the intersection of New Hampshire avenue and M street north.

No. 125. Triangle (area, 983 square feet; unimproved):
Between Nineteenth and Twentieth streets west and at the intersection of New Hampshire avenue and O street north.

No. 126. Triangle (area, 216 square feet; unimproved):
Between Eighteenth and Nineteenth streets west and at the intersection of New Hampshire avenue and Q street north.

No. 126½. Triangle (area, 988 square feet; unimproved):
Between Seventeenth and Eighteenth streets west and at the intersection of New Hampshire avenue and R street north.

No. 127. Triangle (area, 12,264 square feet; unimproved):
Between Seventeenth and Eighteenth streets west and at the intersection of New Hampshire avenue and S street north.

No. 128. Triangle (area, 4,050 square feet; unimproved):
Between Sixteenth and Seventeenth streets west and at the intersection of New Hampshire avenue and T street north.

No. 129. Triangle (area, 5,400 square feet; unimproved):
Between Sixteenth and Seventeenth streets west and at the intersection of New Hampshire avenue and U street north.

No. 130. Triangle (area, 3,700 square feet; unimproved):
Between Fifteenth and Sixteenth streets west and at the intersection of New Hampshire avenue and U street north.

No. 131. Triangle (area, 4,120 square feet; unimproved):
Between Fifteenth and Sixteenth streets west and at the intersection of New Hampshire avenue and W street north.

No. 132. Triangle (area, 8,536 square feet; highly improved):
Between Nineteenth and Twentieth streets west and at the intersection of Connecticut avenue and Q street north. Gradedand sown with grass seed, planted with evergreen and deciduous trees and shrubs; water has been introduced.

No. 133. Triangle (area, 5,988 square feet; highly improved):
Between Seventeenth and Eighteenth streets west and at the intersection of Connecticut avenue and M street north, inclosed with post and chain fence; planted in part with evergreen and deciduous trees and shrubs; a flower bed in the center and water introduced.

No. 134. Triangle (area, 3,025 square feet; unimproved):
Between Seventeenth street and Connecticut avenue and at the intersection of Rhode Island avenue and M street north.

No. 135. *Iowa Circle* (area, 2 acres 9,366 square feet; highly improved):
Between Twelfth and Fourteenth streets west and at the intersection of Vermont and Rhode Island avenues. Inclosed with post and chain fence; gas lamps around and through the circle; lawn surfaces planted with a choice collection of evergreen trees and shrubs; asphalt walks are laid through the park; these walks are in bad condition and need renewal. A large rose jet fountain adorns the center, the coping and basin of which are made of artificial stone composed of Portland cement; two drinking fountains and four iron flower vases are placed at the intersections of walks, and there is a flower border around the main fountain.

No. 136. Triangle (area, 12,170 square feet; highly improved):
Between Twelfth and Thirteenth streets west and at the intersection of Rhode Island avenue and P street north. Inclosed with post and chain fence; planted with dwarf evergreen and deciduous trees and shrubs; water has been introduced.

No. 137. Triangle (area, 868 square feet; highly improved):
Between Ninth and Tenth streets west and at the intersection of Rhode Island avenue and Q street north. Inclosed with post and chain fence, and planted with flowering shrubs.

No. 138. Triangle (area, 9,185 square feet; highly improved):
Between Ninth and Tenth streets west and at the intersection of Rhode Island avenue and Q street north. Inclosed with post and chain fence; planted with evergreen and deciduous dwarf growing trees and flowering shrubs, and water introduced.

No. 139. Triangle (area, 687 square feet; partially improved):
Between Sixth and Seventh streets west, and at the intersection of Rhod
Island avenue and R street north. Planted with deciduous trees only.

No. 140. Triangle (area, 6,630 square feet; unimproved):
Between Sixth and Seventh streets west and at the intersection of Rhod
Island avenue and R street north.

No. 141. Triangle (area, 2,530 square feet; unimproved):
Between Fourth and Fifth streets west and at the intersection of Rhod
Island and New Jersey avenues.

No. 142. Trapezoid (area, 960 square feet; partially improved):
Between L and M streets north and at the intersection of Vermont avenu
and Fourteenth street west. Inclosed with an ornamental light wrough
iron railing; graded and in grass.

No. 143. Trapezoid (area, 960 square feet; partially improved):
Between M and N streets north and at the intersection of Vermont avenu
and Fourteenth street west. Inclosed with post and pipe rail fence; grade
and in grass.

No. 144. Trapezoid (area, 7,450 square feet; highly improved):
Between O and P streets north and at the intersection of Vermont avenu
and Thirteenth street west. Inclosed with post and chain fence; plante
with low-growing evergreen and deciduous trees and shrubs, and wate
has been introduced.

No. 145. Triangle (area, 2,467 square feet; unimproved):
Between Twelfth and Thirteenth streets west and at the intersection o
Vermont avenue and R street north.

No. 146. Triangle (area, 3,300 square feet; unimproved):
Between Eleventh and Twelfth streets west and at the intersection of Ve
mont avenue and S street north.

No. 147. Triangle (area, 4,087 square feet; unimproved):
Between Tenth and Eleventh streets west and at the intersection of Ve
mont avenue and S street north.

No. 148. Triangle (area, 13,664 square feet; unimproved):
Between Ninth and Tenth streets west and T and U streets north and at th
intersection of Vermont avenue and Tenth street west.

No. 149. Triangle (area, 418 square feet; unimproved):
Between Ninth and Tenth streets west and at the intersection of Vermon
avenue and V street north.

No. 150. Triangle (area, 8,170 square feet; unimproved):
Between Twenty-second and Twenty-third streets west and at the interse
tion of New York avenue and C street north.

No. 151. Trapezoid (area, 4,356 square feet; partially improved):
Between Thirteenth and Fourteenth streets west and at the intersection o
New York avenue and H street north. Inclosed with post and chain fence
planted in part with deciduous trees and flowering shrubs.

No. 152. Trapezoid (area, 12,626 square feet; highly improved):
Between Eleventh and Twelfth streets west and at the intersection of Ne
York avenue and I street north. Inclosed with ornamental wrought-iro
railing; lawn surface planted with low-growing evergreen and deciduou
trees and flowering shrubs, and water introduced.

No. 153. Trapezoid (area, 11,877 square feet; highly improved):
Between Tenth and Eleventh streets west, and at the intersection of Ne
York avenue and I street north. Inclosed with light wrought-iron fence
planted with evergreen and deciduous trees and shrubs; a flower-bed an
a terra-cotta fountain basin (carved Paris stone center piece and um
brella jet) are located in this park.

No. 154 (area, 5,726 square feet; highly improved):
Between Ninth and Tenth streets west, and at the intersection of New York avenue and K street north. Inclosed with post and chain fence; planted with low-growing deciduous trees and shrubs, a flower-bed in the center of the lawn, and water introduced.

No. 155. Trapezoid (area, 6,042 square feet, highly improved):
Between Sixth and Seventh streets west and at the intersection of New York avenue and K street north. Inclosed with post and chain fence; planted with evergreen and deciduous dwarf trees and flowering shrubs; a flower-bed in the center, and water introduced.

No. 156. Trapezoid (area, 7,181 square feet; unimproved):
Between Fourth and Fifth streets west and at the intersection of New York avenue and L street north.

No. 157. Trapezoid (area, 7,255 square feet; highly improved):
Between Third and Fourth streets west and at the intersection of New York and New Jersey avenues and M street north. Inclosed with a light iron railing; planted with deciduous trees and shrubs; a fountain with Richmond granite coping is in the center.

No. 158. Triangle (area, 22,609 square feet; unimproved):
Between First and Second streets west and at the intersection of New York avenue and M street north.

No. 159. Triangle (area, 4 712 square feet; unimproved):
Between First street west and North Capitol street and at the intersection of New York avenue and N street north.

No. 160. Triangle (area, 4,712 square feet; unimproved):
Between First street east and North Capitol street and at the intersection of New York avenue and N street north.

No. 161. Triangle (area, 7,618 square feet; unimproved):
Between First and Second streets east and at the intersection of New York York avenue, O and Boundary streets north.

No. 162. Triangle (area, 6,298 square feet; partially improved):
Between Thirteen-and-a-half and Fourteenth streets west and at the intersection of Ohio avenue and C street north. Inclosed with post and chain fence; planted in part with evergreen and deciduous trees and shrubs, and water introduced.

No. 163. Triangle (area, 7,272 square feet; unimproved):
Between Thirteenth and Thirteen-and-a-half streets west and at the intersection of Ohio avenue and C street north. The Bethany Chapel was built on this reservation over eleven years ago.

No. 164. Triangle (area, 4,396 square feet; partially improved):
Between Fifth and Sixth streets west and at the intersection of Louisiana avenue and D street north; graded and partly planted.

No. 165. Triangle (area, 5,307 square feet; partially improved):
Between Third and Fourth streets west and at the intersection of Indiana avenue and D street north; graded and partly planted.

No. 166. Triangle (area, 2,296 square feet; unimproved):
Between First and Second streets west and at the intersection of Indiana avenue and C street north.

No. 167. Triangle (area, 6,450 square feet; unimproved):
Between P and Q streets north and at the intersection of New Jersey avenue and Fourth street west.

No. 168. Trapezoid (area, 5,735 square feet; unimproved):
Between Third and Fourth streets west and at the intersection of New Jersey avenue and O street north.

No. 169. Trapezoid (area, 8,550 square feet; unimproved):
Between Third and Fourth streets west and at the intersection of New Jersey avenue and N street north.

No. 170. Triangle (area, 9,386 square feet; highly improved):
At the intersection of New Jersey avenue and I street north and second street west. Inclosed with post and chain fence; planted with evergreen and deciduous low-growing trees and shrubs, and water introduced.

No. 171. Trapezoid (area, 5,725 square feet; highly improved):
Between H and I streets north and at the intersection of New Jersey avenue and I street and Second street west. Inclosed with post and chain fence; walks and flower-beds laid out, evergreen and deciduous trees and shrubs planted.

No. 172. Trapezoid (area 12,572 square feet; partially improved):
Between G and H streets north and at the intersection of New Jersey avenue and First street west; graded, sown in grass, and partly planted.

No. 173. Trapezoid (area, 5,170 square feet; partially improved):
Between E and F streets north and at the intersection of New Jersey avenue and First street west; graded, sown in grass, and partly planted.

No. 174. Trapezium (area, 11,462 square feet; unimproved):
Between H and I streets south and at the intersection of New Jersey avenue, Canal and First streets east.

No. 175. Trapezoid (area, 4,402 square feet; unimproved):
Between Twelfth and Thirteenth streets west and at the intersection of Maryland avenue and D street south. Inclosed with an upright wooden fence.

No. 176. Triangle (area, 2,090 square feet; unimproved):
Between Eleventh and Twelfth streets west and at the intersection of Maryland avenue and D street south. The brick sidewalks take up this entire reservation.

No. 177. Trapezoid (area, 2,058 square feet; unimproved):
Between Tenth and Eleventh streets west and at the intersection of Maryland avenue and D street south. The brick sidewalks take up this entire reservation.

No. 178. Trapezoid (area, 5,029 square feet; unimproved):
Between Ninth and Tenth streets west and at the intersection of Maryland avenue and D street south. Part of this reservation is occupied by the Baltimore and Potomac Railroad tracks.

No. 179. Trapezoid (area, 4,132 square feet; unimproved):
Between Ninth and Tenth streets west and at the intersection of Maryland avenue and C street south.

No. 180. Trapezoid (area 10,098 square feet; unimproved):
Between Sixth and Seventh streets west and at the intersection of Maryland avenue and C street south.

No. 181. Triangle (area, 22,095 square feet; unimproved):
Between Third and Four-and-a-half streets west and at the intersection of Maryland avenue, B, and Canal streets south.

No. 182. Triangle (area, 8,900 square feet; highly improved):
Between First and Second streets east and at the intersection of Maryland avenue and A street north. Inclosed with post and chain fence; graveled walks have been laid out, and the lawns planted with low-growing trees and flowering shrubs.

No. 183. Triangle (area, 7,820 square feet; partially improved):
Between First and Second streets east and at the intersection of Maryland avenue and B street north. Inclosed with post and chain fence; graded, sodded, and partly planted, flower-bed in center and water introduced.

No. 184. Triangle (area, 12,152 square feet; partially improved):
Between Second and Third streets east and at the intersection of Maryland avenue and B street north. Inclosed with post and chain fence; graded, sodded, and partly planted.

No. 185. Triangle (area, 4,860 square feet; unimproved):
Between Sixth and Seventh streets east and at the intersection of Maryland avenue and D street north.

No. 186. Trapezoid (area, 3,213 square feet; unimproved):
Between Seventh and Eighth streets east and at the intersection of Maryland avenue and D street north.

No. 187. Trapezoid (area, 3,720 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of Maryland avenue and E street north.

No. 188. Trapezoid (area, 4,496 square feet; unimproved):
Between Tenth and Eleventh streets east and at the intersection of Maryland avenue and E street north.

No. 189. Triangle (area, 10,860 square feet; unimproved):
Between Eleventh and Twelfth streets east and at the intersection of Maryland avenue and F street north.

No. 190. Triangle (area, 4,588 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of Maryland avenue and F street north.

No. 191. Triangle (area, 4,095 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Maryland avenue and G street north.

No. 192. Triangle (area, 3,330 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Maryland avenue and G street north.

No. 193. Triangle (area, 2,100 square feet; unimproved):
Between O and P streets south and at the intersection of Delaware avenue and Third street west.

No. 194. Triangle (area, 12,750 square feet; unimproved):
Between Second and Third streets west and at the intersection of Delaware avenue and N street south.

No. 195. Trapezoid (area, 6,039 square feet; unimproved):
Between Second and Third streets west and at the intersection of Delaware avenue and M street south.

No. 196. Trapezoid (area, 25,642 square feet; unimproved):
Between I and K streets south and at the intersection of Delaware avenue and Second street west.

No. 197. Trapezoid (area, 11,340 square feet; unimproved):
Between First and Second streets west and at the intersection of Delaware avenue and H street south.

No. 198. Triangle (area, 4,576 square feet; unimproved):
Between G and H streets south and at the intersection of Delaware avenue and First street west.

No. 199. Triangle (area, 405 square feet; unimproved):
Between F and G streets south and at the intersection of Delaware avenue and First street west.

No. 200. Triangle (area, 4,508 square feet; partially improved):
Between F and G streets north and at the intersection of Delaware avenue and First street east.

No. 201. Trapezoid (area, 23,482 square feet; unimproved):
Between G and H streets north and at the intersection of Delaware avenue and First street east. Occupied by the Baltimore and Ohio Railway Company for a freight-yard.

No. 202. Triangle (area, 4,628 square feet; unimproved):
Between L and M streets north and at the intersection of Delaware avenue and Second street east.

No. 203. Trapezoid (area, 7,093 square feet; unimproved):
Between M and N streets north and at the intersection of Delaware avenue and Second street east.

No. 204. Trapezoid (area, 9,702 square feet; unimproved):
Between First and Second streets east and at the intersection of North Carolina avenue and E street south.

No. 205. Trapezoid (area, 10,368 square feet; unimproved):
Between Sixth and Seventh streets east and at the intersection of North Carolina avenue and B street south.

No. 206. Trapezoid (area, 7,837 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of North Carolina avenue and B street south.

No. 207. Trapezoid (area, 7,406 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of North Carolina avenue and A street south.

No. 208. Triangle (area, 10,556 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of North Carolina avenue and A street north.

No. 209. Trapezoid (area, 8,883 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of North Carolina avenue and B street north.

No. 210. Triangle (area, 7,698 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of North Carolina avenue and B street north.

No. 211. Triangle (area, 10,351 square feet; unimproved):
Between Fifteenth and Sixteenth streets east and at the intersection of North Carolina avenue and C street north.

No. 212. Triangle (area, 21,900 square feet; unimproved):
Between Second and Third streets west and at the intersection of Georgia avenue and S street south.

No. 213. Triangle (area, 20,878 square feet; unimproved):
Between First and Second streets west and at the intersection of Georgia avenue and R street south.

No. 214. Triangle (area 20,234 square feet; unimproved):
Between Half and First streets west and at the intersection of Georgia avenue and R street south.

No. 215. Triangle (area 24,727 square feet; unimproved):
Between South Capitol and Half streets west and at the intersection of Georgia avenue and Q street south.

No. 216. Triangle (area 20,520 square feet; unimproved):
Between South Capitol and Half streets east and at the intersection of Georgia avenue and Q street south.

No. 217. Triangle (area 30,975 square feet; unimproved):
Between Half and First streets east and at the intersection of Georgia avenue and P street south.

No. 218. Triangle (area 10,914 square feet; unimproved):
Between Eighth and Ninth streets east and at the intersection of Georgia avenue and M street south.

No. 219. Triangle (area 10,700 square feet; unimproved):
Between Eleventh and Twelfth streets east and at the intersection of Georgia avenue and K street south.

No. 220. Triangle (area 9,144 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of Georgia avenue and K street south.

No. 221. Triangle (area 10,753 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of Georgia avenue and I street south.

No. 222. Trapezoid (area 6,510 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of Georgia and Kentucky avenues and G street south.

No. 223. Triangle (area 3,937 square feet; unimproved):
Between Fifteenth and Sixteenth streets east and at the intersection of Georgia and Kentucky avenues and G street south.

No. 224. Triangle (area, 15,748 square feet; unimproved):
Between Seventeenth and Eighteenth streets east and at the intersection of Georgia avenue and E street south.

No. 225. Triangle (area, 8,972 square feet; unimproved):
Between Eighteenth and Nineteenth streets east and at the intersection of Georgia avenue and B street south.

No. 226. Triangle (area, 5,395 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of Kentucky avenue and B street south.

No. 227. Triangle (area, 3,850 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Kentucky avenue and B street south.

No. 228. Triangle (area, 5,642 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of South Carolina avenue and C street south.

No. 229. Triangle (area, 5,046 square feet; unimproved):
Between Twelfth and Thirteenth streets east, and at the intersection of South Carolina avenue and C street south.

No. 230. Triangle (area, 2,116 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Kentucky avenue and D street south.

No. 231. Triangle (area, 2,040 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of Kentucky avenue and D street south.

No. 232. Triangle (area, 1,762 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of Kentucky avenue and E street south.

No. 233. Triangle (area, 1,462 square feet; unimproved):
Between Fifteenth and Sixteenth streets east and at the intersection of Kentucky avenue and H street south.

No. 234. Triangle (area, 5,742 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of Tennessee avenue and B street north.

No. 235. Triangle (area, 6,348 square feet; unimproved:
Between Thirteenth and Fourteenth streets east and at the intersection of Tennessee avenue and B street north.

No. 236. Triangle (area, 5,043 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Tennessee avenue and D street north.

No. 237. Triangle (area, 3,250 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of Tennessee avenue and E street north.

No. 238. Rectangle (area, 2 acres 36,181 square feet; unimproved):
Between Twentieth and Twenty-first streets west and B street north and the Potomac River.

No. 239. Triangle (area, 11,400 square feet; unimproved):
At the intersection of Water street, N street south and Sixth street west.

No. 240. Triangle (area, 8,125 square feet; unimproved):
Between L and M streets south and Half and First streets west.

No. 241. Triangle (area, 2,929 square feet; unimproved):
At the intersection of Canal street, H street south, and Half street east.

No. 242. Rectangle (area, 3 acres 1,145 square feet; unimproved):
Between Fifth and Seventh streets east and K and L streets south.

No. 243. Triangle (area, 7,675 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of Water street and M street south.

No. 244. Triangle (area, 3,450 square feet; unimproved):
Between Fifteenth and Sixteenth streets east and at the intersection of Water street and L street south.

No. 245. Trapezoid (area, 22,050 square feet; unimproved):
Between H and I streets south and Half street west and South Capitol street.

No. 246. Rectangle (area, 11 acres 13,840 square feet; unimproved):
Between Four-and-a-half and Sixth streets west and College and Pomeroy streets north, partly planted with deciduous trees of large growth, and sodded.

No. 247. Triangle (area, 625 square feet; unimproved):
Between Fourth and Fifth streets west and at the intersection of Massachusetts avenue and I street north.

No. 248. Triangle (area, 787 square feet; unimproved):
Between G and H streets north and at the intersection of Virginia avenue and I street north.

No. 249. Triangle (area, 1,750 square feet; unimproved):
Between Twenty-sixth and Twenty-seventh streets west and at the intersection of Virginia avenue and H street north.

No. 250. Triangle (area, 1,875 square feet; unimproved):
Between Twenty-fifth and Twenty-sixth streets west and at the intersection of Virginia avenue and H street north.

No. 251. Trapezoid (area 2,394 square feet; unimproved):
Between Twenty-second and Twenty-third streets and at the intersection of Virginia avenue and F street north.

No. 252. Triangle (area, 1,950 square feet; unimproved):
Between Nineteenth and Twentieth streets west and at the intersection of Virginia avenue and D street north.

No. 253. Triangle (area, 1,750 square feet; unimproved):
Between I and K streets north and at the intersection of New Hampshire avenue and D street north.

No. 254. Trapezoid (area, 2,200 square feet; unimproved):
Between K and L streets north and at the intersection of New Hampshire avenue and Twenty-second street west.

No. 255. Triangle (area, 1,536 square feet; unimproved):
Between M and N streets north and at the intersection of New Hampshire avenue and Twenty-first street west.

No. 256. Triangle (area, 1,995 square feet; unimproved):
Between L and M streets north and at the intersection of New Hampshire avenue and Twenty-second street west.

No. 256½. Triangle (area, 1,987 square feet; unimproved):
Between N and O streets north and at the intersection of New Hampshire avenue and Twentieth street west.

No. 257. Trapezoid (area, 1,263 square feet; unimproved):
Between Thirteenth and Fourteenth streets west and at the intersection of Rhode Island avenue and P street north.

No. 258. Trapezoid (area, 1,700 square feet; unimproved):
Between P and Q streets north and at the intersection of Vermont avenue and Thirteenth street west.

No. 259. Trapezoid (area, 1,856 square feet; unimproved):
Between P and Q streets north and at the intersection of Rhode Island avenue and Tenth street west.

No. 260. Trapezoid (area, 3,150 square feet; unimproved):
Between R and S streets north and at the intersection of Vermont avenue and Twelfth street west.

No. 261. Trapezoid (area, 3,045 square feet; unimproved):
Between S and T streets north and at the intersection of Vermont avenue and Tenth street west.

No. 262. Triangle (area, 920 square feet; unimproved):
Between O and P streets north and at the intersection of New Jersey avenue and Fourth street west.

No. 263. Triangle (area, 1,845 square feet; unimproved):
Between L and M streets north and at the intersection of New York avenue and Fifth street west.

No. 264. Triangle (area, 2,090 square feet; unimproved):
At the intersection of New York and New Jersey avenues and M street north.

No. 265. Trapezoid (area, 1,672 square feet; unimproved):
Between North Capitol street and First street east, at the intersection of New York avenue and O street north.

No. 266. Triangle (area, 552 square feet; unimproved):
Between L and M streets south and at the intersection of Delaware avenue and Second street west.

No. 267. Triangle (area, 2,100 square feet; unimproved):
Between K and L streets south and at the intersection of Delaware avenue and Second street west.

No. 268. Trapezoid (area, 700 square feet; unimproved):
Between F and G streets north and at the intersection of New Jersey avenue and First street west.

No. 269. Triangle (area, 825 square feet unimproved):
Between Seventh and Eighth streets east and at the intersection of North Carolina avenue and B street south.

No. 270. Triangle (area, 825 square feet; unimproved):
Between Ninth and Tenth streets east and at the intersection of North Carolina avenue and A street south.

No. 271. Triangle (area, 600 square feet; unimproved):
Between Fourteenth and Fifteenth streets east and at the intersection of North Carolina avenue and B street north.

No. 272. Triangle (area, 1,235 square feet; unimproved):
Between Fifteenth and Seventeenth streets east and at the intersection of Water street and L street south.

No. 273. Triangle (area, 2,592 feet; unimproved):
Between Fifteenth and Sixteenth streets east and at the intersection of Georgia and Kentucky avenues and G street south.

No. 274. Triangle (area, 1,080 square feet; unimproved):
At the intersection of Boundary and Twenty-second street west.

No. 275. Triangle (area, 877 square feet; unimproved):
At the intersection of Boundary and Twenty-first streets northwest.

No. 276. Triangle (area, 687 square feet; unimproved):
At the intersection of Boundary and V streets north and between Seventeenth and Eighteenth streets west.

No. 277. Triangle (area, 437 square feet; unimproved):
At the intersection of Boundary and Tenth streets northwest.

No. 278. Triangle (area, 350 square feet; unimproved):
Between Sixth and Seventh streets west and at the intersection of Boundary and T streets north.

No. 279. Triangle (area, 870 square feet; unimproved):
Between Fourth and Fifth streets west and at the intersection of Boundary and S streets north.

No. 280. Triangle (area, 870 square feet; unimproved):
Between First and Thirds streets west and at the intersection of Boundary and R streets north.

No. 281. Triangle (area, 742 square feet; unimproved):
Between North Capitol street and First street west and at the intersection of Boundary and Q streets north.

No. 282. Triangle (area, 960 square feet; unimproved):
Between North Capitol street and First street east and at the intersection of Boundary and P streets north.

No. 283. Triangle (area, 484 square feet; unimproved):
Between Third and Fourth streets east and at the intersection of Boundary and N streets north.

No. 284. Triangle (area, 725 square feet; unimproved):
Between Sixth and Seventh streets east and at the intersection of Boundary and M streets north.

No. 285. Triangle (area, 700 square feet; unimproved):
Between Ninth and Tenth streets east and at the intersection of Boundary and L streets north.

No. 286. Trapezoid (area, 1,053 square feet; unimproved):
Between Eleventh and Twelfth streets east and at the intersection of Boundary and K streets north.

No. 287. Triangle (area, 600 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Boundary and I streets north.

No. 288. Triangle (area, 3,932 square feet; unimproved):
Between Thirteenth and Fourteenth streets east and at the intersection of Virginia avenue and Water street south.

No. 289. Triangle (area, 3,250 square feet; unimproved):
Between Twelfth and Thirteenth streets east and at the intersection of N and Water streets south.

No. 290. Triangle (area, 9,108 feet; unimproved):
Between U and V streets south and at the intersection of Water street and Half street west.

No. 291. Triangle (area, 1,500 square feet; unimproved):
Between First and Second streets east and at the intersection of Georgia avenue and O street south.

No. 292. Triangle (area, 1,750 square feet; unimproved):
Between R and S streets south and at the intersection of South Capitol and Water streets.

No. 293. Triangle (area, 9,954 square feet; unimproved):
Between T and U streets south and at the intersection of Water and Half streets west.

No. 294. Triangle (area, 1,736 square feet; unimproved):
Between Maryland avenue and B street south and between Canal and Third streets west.

No. 295. Pentagon (area, 12, 372 square feet; unimproved):
Between Maryland avenue and B street south and in the center of the canal.

No. 296. Trapezoid (area, 18,572 square feet; unimproved):
Between Second and Third streets west and in the center of the canal.

No. 297. Triangle (area, 1,798 square feet; unimproved):
Between Canal street and the intersection of B and Second streets southwest.

No. 298. Pentagon (area, 38,787 square feet; unimproved):
At the intersection of Second and C streets southwest, and in the center of the canal.

No. 299. Triangle (area, 1,680 square feet; unimproved):
At the intersection of First and C streets southwest and in the center of the canal.

No. 300. Rhomboid (area, 32,214 square feet; unimproved):
At the intersection of First and C streets, Delaware avenue and D street southwest and in the center of the canal.

No. 301. Triangle (area, 10,500 square feet; unimproved):
Between Canal street and the intersection of First and D streets southwest.

No. 302. Triangle (area, 556 square feet; unimproved):
At the intersection of Delaware avenue and D street southwest and in the center of the canal.

No. 303. Pentagon (area, 1 acre 6,726 square feet; unimproved):
Between South Capitol street and Delaware avenue and in the center of the canal.

No. 304. Triangle (area, 2,280 square feet; unimproved):
At the intersection of I and Half streets southwest and on the west side of Canal street.

No. 305. Triangle (area, 2,100 square feet; unimproved):
At the intersection of Canal and N street south and First street west.

No. 306. Triangle (area, 405 square feet; unimproved):
At the intersection of Virginia avenue, Second and E streets southwest.

No. 307. Pentagon (area, 9,200 square feet; partially improved):
At the intersection of E and Canal streets and in the center of South Capitol street. This park has been sown in grass and partly planted.

No. 308. Triangle (area, 1,905 square feet; partially improved):
At the intersection of Canal and E streets southeast. The curbing and sidewalks have been laid.

No. 309. Trapezoid (area, 3,745 square feet; unimproved):
At the intersection of South Capitol, Canal, and H streets southwest.

No. 310. Triangle (area, 5,700 square feet; unimproved):
At the intersection of South Capitol, Canal, and H streets southwest.

No. 311. Parallelogram (area, 33,150 square feet; unimproved):
Between Canal and Half streets southwest and in the middle of the old canal bed, south of Reservation No. 17.

No. 312. Parallelogram (area, 39,695 square feet; unimproved):
Between Half and First streets southeast and in the middle of the old canal bed, south of Reservation No. 17.

No. 313. Trapezoid (area, 7,862 square feet; unimproved):
Between First street and New Jersey avenue southeast and in the middle of the old canal bed, south of Reservation No. 17.

No. 314. Trapezoid (area, 24,522 square feet; unimproved):
Between New Jersey avenue and the intersection of Canal and I streets southeast, in the middle of the old canal bed.

No. 315. Triangle (area, 1,520 square feet; unimproved):
At the intersection of New Jersey avenue, Canal and I streets southeast.

No. 316. Triangle (area, 19,782 square feet; unimproved):
At the intersection of Canal, I, and Second streets southeast.

No. 317. Trapezoid (area, 20,140 square feet; unimproved):
At the intersection of I street and Second streets southeast and in the middle of the old canal bed.

No. 318. Trapezoid (area, 3,277 square feet; unimproved):
At the intersection of K and Second streets southeast and in the middle of the old canal bed.

No. 319. Rectangle (area, 25,175 square feet; unimproved):
Between K and L streets southeast, in the middle of the old canal bed at Second street.

No. 320. Rectangle (area, 30,400 square feet; unimproved):
Between L and M streets southeast, in the middle of the old canal bed at Second street.

No. 321. Rectangle (area, 1 acre 15,340 square feet; unimproved):
Between M and N streets southeast, in the middle of the old canal bed at Second street.

No. 322. Triangle (area, 22,400 square feet; unimproved):
At the intersection of New Jersey avenue, M and Second streets southeast.

No. 323. Triangle (area, 5,180 square feet; unimproved):
At the intersection of Georgia avenue and Fourth and N streets southeast.

No. 324. Triangle (area, 1,827 square feet; unimproved):
At the intersection of Georgia avenue, N, Fifth, and Canal streets southeast.

No. 325. Rectangle (area, 1 acre 820 square feet; unimproved):
Between L and M streets southeast, and in the middle of the old canal bed in line of Sixth street east.

No. 326. Rectangle (area, 1 acre 41,000 square feet; unimproved):
Between M and N streets southeast, in the middle of the old canal bed in line of Sixth street east.

No. 327. Rectangle (area, 1 acre 39,740 square feet; unimproved):
Between M street southeast and the Eastern Branch of the Potomac, in the middle of the old canal bed and in line of Sixth street east.

No. 328. Garfield Circle (area, 6,361 square feet; highly improved):
At the junction of Maryland avenue with First street southwest. The statue of James A. Garfield, late President of the United States, has been erected in this circle. The pedestal was erected by the United States and the statue by the Army of the Cumberland.

APPENDIX X X.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

X X 1.

BRIDGE OF THE KENTUCKY AND OHIO BRIDGE COMPANY ACROSS THE OHIO RIVER BETWEEN CINCINNATI, OHIO, AND COVINGTON, KENTUCKY.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 7, 1886.

SIR: I have the honor to submit herewith a report dated October 1, 1886, with accompanying papers, from the special Board of Engineers constituted September 13, 1886, for the purpose of considering the plans presented by the Kentucky and Ohio Bridge Company for a bridge over the Ohio River between Cincinnati, Ohio, and Covington, Ky.

On May 20, 1886, a special act of Congress was approved, authorizing the construction of a bridge, subject to the limitations and restrictions of the general law for bridges, over the Ohio.

The reduction from the height of spans required by the general law proposed by the bridge company, will, it appears, work hardship to steamers during periods when the stage of the river is 50 feet or more above low water, as the pilot-houses of some of them will not then pass under the bridge, and there being no draw openings such steamers will be unable to come to their landings, and will be compelled to remain below the bridge and be shut out from access to the portion of the river above the bridge where they have been accustomed to land their passengers and freight.

In my opinion the Secretary of War has the right to insist upon the adoption of the greater height required by the general law.

The Board does not consider the site selected for the proposed bridge unfavorable for the interests of navigation, but parties in the interest of navigation protest against the construction of a bridge that does not

conform to the requirements of the general law for bridges over the Ohio, and the conflict of interests involved deserves careful consideration.

The general law regulating the construction of bridges over the Ohio River requires that the bridge should be at least 53 feet above local highest water measured to the lowest part of the span, or 13 feet higher than that proposed by the bridge company.

If the act of May 20, 1886, authorizes a bridge of the same height as the Covington and Cincinnati Suspension Bridge, and does not, at the same time, require the bridge to be 53 feet above high water, then no reason is known to this office why the plans herewith should not be approved.

Duplicates of the drawings have been made in this office and are herewith.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
in Charge of Office.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.

[First indorsement.]

WAR DEPARTMENT, *October* 8, 1886.

Respectfully referred to the Acting Judge-Advocate-General for report.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

WAR DEPARTMENT,
JUDGE-ADVOCATE-GENERAL'S OFFICE,
Washington, D. C., October 11, 1886.

Respectfully returned to the Secretary of War.

The question presented to this office "for examination and report" is understood to relate to the construction of the acts of Congress in regard to the elevation of bridges across the Ohio River.

The general law now in force upon the subject is contained in the act of Congress of December 17, 1872 (17 Stats., 398), as amended by the act of February 14, 1883 (22 Stats., 414), and, so far as concerns the question under consideration, is as follows:

Every such bridge shall have at least one channel-span placed over that part of the river usually run by descending coal fleets. * * * Said channel-span shall be at least 40 feet above local highest water, measured to the lowest part of the span, and shall be at least 90 feet above low water, in bridges built above the mouth of the Big Sandy River, and at least 100 feet above low water in bridges built below the mouth of the Big Sandy River, measured to the lowest part of the span: *Provided, however*, That all bridges over the Ohio River below the Covington and Cincinnati Suspension Bridge shall have, in addition to the channel-span prescribed above, a pivot-draw. * * * *Provided further*, That in lieu of the high draw prescribed above, bridges over the Ohio River below the Covington and Cincinnati Suspension Bridge may be built as continuous bridges [viz, without a draw], with a clear height of 53 feet above local highest water, measured to the lowest part of the channel-span.

By an act to authorize the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company to erect a bridge across the Ohio River, approved May 20, 1886, it was enacted—

That the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company, and its successors or assigns, are hereby authorized and empowered to erect a bridge across the Ohio River between Covington, Ky., and Cincinnati, Ohio, subject to the limitations and restrictions of the general law regulating the construction of bridges over the Ohio River: *Provided, however,* That said bridge shall not be of less elevation than the Covington and Cincinnati Suspension Bridge, and may be constructed without a pivot draw-span.

The bridge which the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company are about to construct under the provisions of the act last above quoted must therefore conform to the general law in every respect, except that it may be built without a pivot draw-span, and that it shall not be of a less elevation than the Covington and Cincinnati Suspension Bridge. In these particulars the general law is, in my opinion (so far as regards this bridge), repealed by the proviso in the special act.

The proposed bridge is to be located below the Covington and Cincinnati Suspension Bridge, and, under the general law above quoted, would be required to have a clear height of 53 feet above local highest water; but under the proviso of the special act the Covington and Cincinnati Suspension Bridge is made the standard as regards elevation.

The act says the proposed bridge "shall not be of less elevation than the Covington and Cincinnati Suspension Bridge." If, therefore, the proposed bridge be of an elevation equal to, or greater than that of the Covington and Cincinnati Suspension Bridge the law will, in that respect, have been complied with.

Section 4 of the general law above cited provides, among other things, that any person or company authorized to construct a bridge across the Ohio River shall submit to the Secretary of War, for his examination, a design and drawings of the bridge and piers, and maps of the location, etc.

Said maps and drawings shall be referred to a Board of Engineers for examination and report, which Board shall personally examine the site of the proposed bridge * * * and if said Board of Engineers report that the site is unfavorable, the Secretary of War shall be authorized, on the recommendation of said Board, to order such changes in the bridge or its piers or such guiding dikes or other auxiliary works as may be necessary * * * for the security of navigation; and the proposed bridge shall only be a legal structure when built as approved by the Secretary of War.

The authority here conferred upon the Secretary of War "to order changes in the bridge, or its piers, dikes, etc.," does not, in my opinion, confer upon him the power to order a change in the height of the bridge, above high or low water mark. Such a construction of the law would make section 4 repugnant to section 2 of the same act—which prescribes the required height—and would virtually authorize the Secretary of War to disregard the provisions of section 2 in regard to the height of any bridge across the Ohio River.

In this particular case, as before stated, the proviso at the end of section 2 of the act of February 14, 1883, was repealed by the proviso in the special act of May 20, 1886, but the latter act does not enlarge the scope of section 4 of the act of February 14, 1883. By the act of May 20, 1886, the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company is empowered to build a bridge which shall not be of less elevation than the Covington and Cincinnati Suspension Bridge; and it would seem that, under the law, they cannot be required to build it of a greater elevation; in other words, that the proper construction of the act of

May 20, 1886, is that the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company would be authorized, upon satisfying other provisions of law, to bridge the Ohio River at the elevation of the Covington and Cincinnati Suspension Bridge.

Under the rule of the War Department of July 31, 1886, a copy of the minutes of the organization of the company under its charter and an extract from the company's minutes, showing the names of the present officers of the company, are required. Further, the fact that the company has accepted the provisions of the act of Congress approved May 20, 1886, chapter —, should be established by an extract from the minutes of the corporation. All of these documents should be authenticated, under the seal of the company, by the proper officer having charge of its records.

The act of Congress authorizes the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company to build the bridge in question, but the accompanying proceedings of the Board of Engineers, required under the acts of Congress of December 17, 1872, and February 14, 1883, show that they have examined certain plans of the Kentucky and Ohio Bridge Company, a corporation which has no connection with the grant under consideration.

In the opinion of this office evidence should be submitted from the minutes of the company that the plans submitted to and passed upon by the Board of Engineers have the approval of and are submitted by the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company to the Secretary of War, under the provisions of the act of Congress approved May 20, 1886.

G. NORMAN LIEBER,
Acting Judge-Advocate-General.

REPORT OF BOARD OF ENGINEERS.

CINCINNATI, OHIO, *October* 1, 1886.

SIR: The Board of Engineers constituted by Special Orders No. 134, Headquarters Corps of Engineers, September 13, 1886, for the purpose of considering the plans presented by the Kentucky and Ohio Bridge Company for a bridge over the Ohio River between Cincinnati, Ohio, and Covington, Ky., met at Cincinnati, Ohio, on September 29 and 30 and October 1.

The special instructions of the Board, as given in letter of Chief of Engineers, dated September 14, 1886, are as follows:

> The Board of Engineers constituted, etc., * * * is convened to consider and report upon plans and location of a bridge proposed to be erected across the Ohio River between the cities of Covington, Ky., and Cincinnati, Ohio.
>
> * * * * * * *
>
> It is requested that the Board give the subject of the plans and location of the proposed bridge full and careful consideration, and it is suggested that an opportunity be given, by holding public sessions after notice in newspapers or otherwise, as may be deemed best, for the presentation of the views of all parties interested in the matter, inviting the opinions, either orally or in writing, of those opposed to as well as those favoring the construction of the bridge in question.
>
> * * * * * * *
>
> As early a report as is consistent with due regard to the important duty committed to Board * * * is desired.

The meeting of September 30 was a public one held in accordance with notice given. At this meeting were present representatives of the

bridge and railroad companies, and the coal and packet interests. The local shore interests were also presented. An opportunity was given for a full expression of opinions favorable or adverse to the plans and location of the bridge in question.

On September 29, in company with representatives of the bridge company, and on September 30, in company with a delegation representing the coal, towing, and packet interests of the Ohio and Mississippi rivers, the Board made thorough inspections of the proposed bridge site and the river in its vicinity.

After a full consideration of all the facts and opinions presented, the Board respectfully present the following report:

From correspondence before the Board it appears that originally a corporation designated the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company requested authority to construct a bridge in accordance with the general law governing the construction of bridges over the Ohio River, as modified by an act of Congress approved May 20, 1886, which latter act provides "that said bridge shall not be of less elevation than the Covington and Cincinnati Suspension Bridge, and may be constructed without a pivot draw-span." Awaiting the receipt of certain required information, action on the application of the above-mentioned company was deferred.

Subsequently a corporation known as the Kentucky and Ohio Bridge Company, through its president, Mr. J. E. Gates, transmitted to the Secretary of War with other papers its acceptance of the provisions of the acts of Congress of December 17, 1872, and February 14, 1883, authorizing the construction of bridges over the Ohio River, and requested the appointment of a Board of Engineers for considering plans. No evidence being furnished as to the legal status of the Kentucky and Ohio Bridge Company in relation to the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company, action on the request of Mr. Gates was deferred.

In August, 1886, Mr. J. E. Gates, president Kentucky and Ohio Bridge Company, on behalf of his company reported to the Secretary of War that the application of his company for the appointment of a Board of Engineers to consider plans for a bridge over the Ohio River between Cincinnati and Covington had nothing to do with that of the Covington and Cincinnati Elevated Railway and Bridge Company, but subsequently the differences between these two companies appear to have been settled, and by extracts from the records of the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company, it appears that all the rights of such company under its charter and the special act of Congress approved May 20, 1886, have been assigned to the Kentucky and Ohio Bridge Company.

From the above it will appear that the Board are to consider the plans and location of the proposed bridge in their relation to the general bridge laws of December 17, 1872, and February 14, 1883, as modified by the special act of May 20, 1886.

The general bridge law governing the construction of bridges over the Ohio River, below the Cincinnati and Covington Suspension Bridge, as contained in the act of Congress approved December 17, 1872, and amended in act approved February 14, 1883, imposes the following conditions, viz:

First. The axis of the bridge shall be at right angles to the current at all stages.

Second. All the spans shall be through spans.

Third. There shall be at least one channel-span placed over that part of the river usually run by descending coal fleets. Said channel-span to give a clear water-way between the piers of 500 feet, measured on the low-water line. Said channel-span shall be at least 40 feet above local highest water, measured to the lowest part of the span, and at least 100 feet above low water, measured to the lowest part of the span.

Fourth. The bridge shall have, in addition to the channel-span prescribed above, a pivot-draw giving two clear openings of 160 feet each, measured at right angles to the current at high stages, and located in a part of the bridge that can be safely and conveniently reached at such stages; that said draw shall be provided with suitable rest-piers above and below the pivot-pier, and suitable floats or crib-work connecting said rest-piers with the pivot-pier, to enable boats to pass through said draw with safety; that in case said draw-span is near either shore, the bridge company, by purchase or otherwise, shall extinguish the right of mooring boats or other water craft to the adjacent shore for a distance of at least 700 feet above, and 700 feet below the bridge.

Fifth. That in lieu of the high draw prescribed above, bridges over the Ohio River below the Covington and Cincinnati Suspension Bridge may be built as continuous bridges, with a clear height of 53 feet above local highest water, measured to the lowest part of the channel-span.

Sixth. That the piers of the high span and the piers of the draw shall be built parallel with the current at that stage of the river which is most important for navigation, and that no ripraps or other outside protection for imperfect foundation will be permitted in the channel-way of the high span or of the draw openings.

Seventh. That for the proper information of the Secretary of War certain maps and drawings shall be submitted to him, which shall be referred to a Board of Engineers for examination and report.

The following is the list, viz:

(1) A design and drawings of the bridge and piers.

(2) A map of the location giving, for the space of at least 1 mile above and 1 mile below the proposed location, the topography of the banks of the river and the shore-lines at high and low water.

(3) Maps drawn on the scale of 1 inch to 200 feet, giving for a space of one-half a mile above the line of the proposed bridge and a quarter of a mile below, an accurate representation of the bottom of the river, by contour lines 2 feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and direction of the currents at low water, at high water, and at least one intermediate stage, by triangulated observations on suitable floats; and showing the locations of other bridges in the vicinity, and such other information as the Secretary of War may require.

On May 20, 1886, a special act of Congress was approved authorizing the construction of a bridge between Covington and Cincinnati, subject to the limitations and restrictions of the general law, modified by the following provision:

> *Provided, however,* That said bridge shall not be of less elevation than the Covington and Cincinnati Suspension Bridge, and may be constructed without a pivot-draw span.

The effect of this special act is to authorize the construction of a bridge with continuous spans at a height of only 40 feet above high water, instead of 53 feet, as provided by the general law; in all other details the general law is to govern.

An examination of the maps and the site of the proposed bridge, together with such information as could be obtained from the engineers of the bridge and the navigators of the river, shows that the proposed bridge would conform or not to the requirements of the laws as follows, viz:

The axis of the bridge is not at right angles to the current at all stages, nor could it be so placed, as the direction of the current varies with different stages.

The current observations as plotted on the maps show a deviation from the prescribed right angle, varying from about 4 degrees to 10 degrees. The observations were not made over the whole width of the river, nor at all the stages required by law. It is asserted by the engineers of the bridge that at the highest stages the bridge axis is at right angles to the current. Whatever small deviation there may be is not considered of very great importance.

The channel-span is 507 feet and 9 inches at low water, which gives a clear water-way of at least 500 feet, measured at right angles to the current.

The lowest part of the channel is placed at a height of 40 feet above the high water of 1832, which is the height of the Covington and Cincinnati Suspension Bridge, and 102¼ feet above the low water of 1881.

The local highest water at Cincinnati was reached in 1884, when it was 7 feet and three-quarters of an inch above the high water of 1832.

As the flood of 1832 was the highest water known at the time of the passage of the bridge laws above referred to, it is presumed that measurements should be made from that level.

The bridge being placed as high as the suspension bridge would seem to meet the requirements of the special act.

The special act, however, is ambiguous on this point, for while prescribing that the bridge shall not be lower than the suspension bridge, it does not state that it may be as low, and the general law would require the bridge to be 13 feet higher.

The requirements of the laws appear therefore to have been substantially fulfilled in the plans of the bridge.

The reduction from the height of spans as required by the general law will, it appears, work some hardship to steamers during the periods when the stage of the river is 50 feet or more above low water, as the pilot houses of some of them will not pass under the bridge, and there being no draw-opening such steamers will be unable to come to their landings and be compelled to remain below the bridge.

While a less height is permitted by the special law passed in the interest of the bridge company, it is considered the Secretary of War has the right to insist upon the adoption of the greater height required by the general law. To obtain this height is not impossible. It would greatly increase the cost of the bridge both in building and use; but to have the greater height would prevent interference with the existing interests of the packet-boats which, by the adoption of the less height, would at certain stages be shut out from access to the portion of the river above the bridge, where they have hitherto been accustomed to land their passengers and freight.

As usual in such cases the Board finds a conflict of interests, all important, some more, some less, but all deserving careful consideration. This the Board has endeavored to give.

If the question were simply one of building a bridge across the river between Cincinnati and the Kentucky side, in the reach between the existing suspension bridge and the Cincinnati Southern bridge, a loca-

tion nearer the latter would be preferred. It is concluded, however, that under the law the Board is restricted to a consideration of the particular location selected by the company for the bridge. It may not be out of place to state the reasons for this opinion.

Section 4 of the Ohio River bridge law of December 17, 1872, authorizes the Secretary of War, under certain conditions, to make modifications as to the "location" of a bridge. The later law of February 14, 1883, amending the former, struck out the fourth section just referred to, and confines the attention of the Board of Engineers and the Secretary of War to the particular "site" which may have been selected by interested parties, and makes provision, not for a change of site if the site be "unfavorable," but for such "changes in the bridge or its piers, or for the guiding dikes or other auxiliary works, as may be necessary for the security of navigation."

In this particular case the Board does consider the site unfavorable for the interests of navigation. If it were free to state what, in its opinion, would be the best change to be made "in the bridge or its piers," it would recommend an increase of the width of the central span to 600 feet. This change would remove the objections of those using the river for boating coal. An increase of width of 50 feet, or even 25 feet, would be a decided change for the better. The Board, however, is of the opinion that such increase of width of span is not contemplated by the existing law, and to give it would be a concession on the part of the bridge company entirely optional with the company. In this case recourse to "guiding dikes or other auxiliary works" would be of no avail unless the provision of a steam-tug to be constantly in waiting for the assistance of tows passing the bridge, could be required under the terms of the law.

That this is the view taken by the parties proposing to build the bridge is shown by the fact that the Board on its arrival finds a particular site selected for its consideration, contracts made, and in process of execution for the building of piers, even while the Board is performing the duty assigned it.

The following papers required by the "Rules to be observed when application is made pursuant to an act of Congress for the approval by the Secretary or War of plans for a bridge or a right of way, or other privilege," dated War Department, July 31, 1886, are transmitted with this report. But as to the legal sufficiency of these papers the Board expresses no opinion. The papers marked 1 and 2 are a part of those transmitted to the Board for its information:

(1) Certified copy of an act to incorporate the Kentucky and Ohio Bridge Company.

(2) Extracts from the record-book of the Kentucky and Ohio Bridge Company, showing organization, names of present officers, and acceptance by the company of the provisions of the acts of Congress of the United States, approved December 17, 1872, and February 14, 1883, relating to the construction of bridges over the Ohio River.

(3) Certificate that the notice of intention to build has been properly given by the company as required by law.

(4) Certified extract from the records of the Covington and Cincinnati Elevated Road, Transfer and Bridge Company, reciting that said company has transferred to the Kentucky and Ohio Bridge Company all its rights and privileges, under the act of Congress, May 20, 1886, and relinquished to said company its right to erect a bridge under its charter and the act of May 20, 1886, between Covington and Cincinnati. These extracts also show the acceptance by the Kentucky and Ohio Bridge Company through its vice-president of the transfer and assignment.

There is also transmitted herewith letters received from the Louisville Board of Trade and the Winifrede Coal Company, protesting against the construction of a bridge between Covington and Cincinnati which does not conform to the requirements of the general law for bridges

over the Ohio River; also one tracing, showing additional current observations, and two blue prints giving general plan of bridge and piers.

Certain statistics as to the magnitude and importance of the coal interests on the river are expected from their representatives, which will be forwarded as soon as received.

The papers furnished for the information of the Board are returned herewith.

Respectfully submitted.

WM. P. CRAIGHILL,
Lieut. Col. of Engineers.
AMOS STICKNEY,
Major of Engineers.
A. MACKENZIE,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

SUPPLEMENTAL REPORT OF BOARD OF ENGINEERS.

CINCINNATI, OHIO, *October* 15, 1886.

SIR: The Board of Engineers constituted by paragraph 1 of Special Order, No. 134, current series, from the Office of the Chief of Engineers, to consider the plans and location of the bridge proposed to be erected across the Ohio River between the cities of Covington, Ky., and Cincinnati, Ohio, having submitted a report dated Cincinnati, October 1, 1886, reassembled at that city October 13, 1886, in accordance with the following instructions, which were received by the senior member in Baltimore, Md., October 11, 1886, viz:

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 9, 1886.

SIR: The inclosed copy of a communication from this office to the Secretary of War, dated October 8, 1886, approved by him, in reference to the proposed bridge across the Ohio River between Covington and Cincinnati, is furnished for the information and guidance of the Board of Engineers constituted by paragraph 1 of Special Orders, No. 134, Headquarters Corps of Engineers, current series, and reconvened by paragraph 1 of Special Orders, No. 149, Headquarters Corps of Engineers, of this date, of which you are the presiding officer.

The instructions of the Secretary of War are that the Board be reconvened at the earliest practicable moment without reference to the other duties of the members composing it, and that it report at as early a day as the proper consideration of the subject will permit.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
in Charge of Office.

Lieut. Col. W. P. CRAIGHILL,
Corps of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., October 8, 1886.

SIR: Referring to the plans and location of the bridge proposed to be erected across the Ohio River between the cities of Covington, Ky., and Cincinnati, Ohio, now before the War Department, it is respectfully recommended that the Board of Engineers constituted by paragraph 1 of Special Orders, No. 134, current series, from this office, be reconvened for the purpose of further investigating and reporting upon the effect the construction of the bridge will have upon the navigable interests of the Ohio River.

To this end it would seem desirable that the Board should ascertain the duration of the periods of high water when, as is alleged, a bridge of the elevation proposed by the plan submitted will interfere with steamboat navigation; and also from data, which it is believed can be readily obtained, give an approximate estimate of the damage to commerce resulting therefrom.

The Board should be authorized to call upon the engineer officer in charge of the improvement of the Ohio for any information he may possess in reference to the questions involved, and also for such aid and assistance as his knowledge and experience may enable him to furnish.

It is suggested that the Board be required to state its views and recommendations in regard to the propriety of constructing a bridge upon the proposed plan, taking into consideration the magnitude of the interests involved.

If approved, the Board will be reconvened by a telegram from this office.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
In Charge of Office.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.

The Board has the honor to submit the following supplemental report:

The information called for with regard to the periods of time when the river is at such a stage as to interfere with steamboat navigation is contained in the following table:

Number of days in each year from 1859 *to* 1886 *inclusive when a bridge with height proposed by plans of the Kentucky and Ohio Bridge Company* (40 *feet above high water,* 1832) *for a bridge over the Ohio River between Covington and Cincinnati would prevent the passage of boats having tops of pilot-houses* 53 *feet above the water-surface:*

Year.	No. of days.	Year.	No. of days.	Year.	No. of days.	Year.	No. of days.
1859	12	1866	0	1873	0	1880	5
1860	0	1867	21	1874	0	1881	3
1861	0	1868	0	1875	7	1882	10
1862	14	1869	0	1876	3	1883	17
1863	0	1870	10	1877	7	1884	23
1864	0	1871	0	1878	0	1885	9
1865	9	1872	0	1879	0	1886	13

As bearing upon the subject of damage to commerce from the fixing of the height of the bridge as proposed the following letter of Captain Holloway is submitted:

CINCINNATI, OHIO, *October* 14, 1886.

DEAR SIR: In answer to the several questions propounded by your Board I beg to submit the following answers:

The steamboats which would be obliged to pass the proposed bridge and their tonnage are as follows:

Steamers.	Capacity for freight.	Capacity for passengers.
Southern Transportation Line.		
	Tons.	
Guiding Star	1,500	150
Charles Morgan	1,400	150
Thomas Sherlock	1,600	160
Paris C. Brown	1,200	135
Golden Rule	1,400	125
Mary Houston	1,400	150
U. P. Schenck	1,200	125
Memphis and Cincinnati Packet Company.		
De Soto	1,200	125
Ohio	900	150
Buckeye State	1,100	150
James W. Gaff	700	125
United States daily mail line between Cincinnati and Louisville.		
Fleetwood	1,000	175
City of Madison	800	150
City of Vevay	500	100
General Pike	500	100
Hornet	350	50

In answer to the questions regarding amount of freight and number of passengers carried, number of trips, and height of pilot-houses I would say.

The Louisville mail-line steamers and Madison packets import to and export from Cincinnati 350 tons of freight daily, and their passenger list in and out of this port will approximate 200 daily. The Louisville boats each make one trip a day, and the Madison packets make three trips a week each. We have two Memphis boats in and out per week; they bring in and take out of Cincinnati 2,000 tons of freight per week and 300 passengers. The New Orleans boats bring to and take away from this port 2,500 tons of freight per week and 250 passengers.

The height of the pilot-houses on our regular steamers is 53 feet. Of the New Orleans steamers 55 feet. At extreme high water, to carry on our business, we should have 53 feet space for our daily packets.

The public landing place for steamers carrying on the river traffic of this port is bounded as follows:

East by Broadway, west by Main street, north by Front street, and south by low-water mark. This, constituting a space of 1,000 feet running parallel with the river, was set apart and has been held as a public steamboat wharf since the incorporation of Cincinnati as a city. This wharf is above the suspension bridge.

When high water precludes the passage under the suspension bridge we then handle our traffic at Vine and Race streets immediately below (and above the proposed site of the proposed bridge), which is the only place below the suspension bridge that steamboat traffic can be handled at all. If the new bridge is built at the point contemplated by its projectors at the same height as the suspension bridge and without a draw it would simply mean that all steamboats plying between this port and points below would be absolutely shut out from this port during a stage of water in the Ohio River of 50 feet or over. There is no available landing at any point in the corporation of Cincinnati below the proposed bridge site where traffic and merchandise can be handled by our steamboats, for the reason that every bit of space is occupied by coal harbors and other private interests. To do a steamboat traffic at any point in the corporation of Cincinnati below this proposed bridge would be impracticable.

The additional cost to each boat, properly manned with a full crew and with an ordinary trip of freight and passengers, by reason of their failure to pass under the proposed new bridge in time of high water, would be $200 per day for each boat while delayed in getting to the city wharf proper.

At the time of the passage of the special act under which the Kentucky and Ohio Bridge Company propose building a bridge with height 13 feet less than is required by the general bridge law and without a draw, the interests I represent were not consulted, nor were any other steamboat interests at this port consulted.

The present height of pilot-houses cannot be reduced for the reason that the main cabins of the steamers can not be lowered without detriment to the freight, stowage capacity on deck, and the officers' quarters, or texas, must be erected upon the main cabins, and upon that the pilot-house has to be built in order that the pilot may see fore and aft and abreast of him, which the demands of safe navigation require.

All of which is respectfully submitted.

C. M. Holloway,
General Manager U. S. Mail Line and Prest.
Memphis and Cinti. Packet Co., and
Supt. Cinti. Portsmouth and
Big Sandy Packet Co.

A. Mackenzie,
Major of Engineers.

The Board is called upon by the supplemental instructions to state its views and recommendations in regard to the propriety of constructing a bridge upon the proposed plan, taking into consideration the magnitude of the interests involved.

The questions which arise in the discussion of a proper method of bridging a river like the Ohio affect not only the parties directly concerned in the cost of building the bridge and those whose property is emperiled by it, but also the very large portion of the community which is interested in prices of products and merchandise, the delivery of which is made more difficult and therefore more costly by the existence of a bridge.

These questions have been discussed for years, and one of the results was the framing and enacting by the national Congress of a general bridge law, which permitted the building of bridges over the Ohio River,

but imposed certain conditions for the protection of the interests of river commerce. The provisions of this law appear to have been adopted as the best possible solution of the difficult problem of satisfying as far as possible all parties interested.

The enactment of the Ohio River bridge law had the effect of producing a sense of security among those who were interested in the navigation of the river, and made them feel that there was a well-defined limit to the extent to which any future bridge would be allowed to obstruct their traffic.

In the case of the proposed bridge now under consideration it appears a special act has been secured, which contemplates a release from certain restrictions of the general law. It is stated by the river interests that they were not represented before Congress and had no knowledge of this special law until after its passage. The Board consider this special law to be permissive and not mandatory, giving the Secretary of War authority to allow a modification of the general law if he should consider the same proper.

If the provisions of the general bridge law are such as to protect the interests of all parties, it would not seem expedient, excepting in the case of abundant proof being presented, to change the conditions for the benefit of one party and to the detriment of others. It does not appear to the Board on the evidence before it that in the present instance there is any other reason for the desired modification of the law than the wish of the company to decrease the cost of their bridge.

If the general law is set aside in one case it could as easily be set aside in many others, and the general law itself would be an injury rather than a benefit, as it gives the river interests a sense of security which prevents them from taking active and timely measures for their own protection in special cases.

The river at the site of the proposed bridge is now without obstruction of any kind. With a bridge of almost any description a danger to navigation will be created, more pronounced on account of the location in a bend of the river, and in a harbor between two cities, and where the smoke from manufactories at times materially interferes with navigation. A clear water-way of 500 feet on a straight reach of river is considered reasonably safe; in a bend which requires the flanking position of a tow, the navigators contend that a water-way of 600 feet would be required to afford the same degree of safety.

With regard to the height of the bridge, it is to be observed that the distance of 53 feet above high water was fixed in the general law to simply leave room under continuous bridges for the pilot-houses of large steamers, the chimneys being lowered. The Board is informed that on some steamers the pilot-houses are 55 feet above the water.

The usual landing place for the large packet-boats, which ordinarily do not ascend above Cincinnati, is just above the suspension bridge; but there is an entirely practicable and convenient landing just below the suspension bridge, and above the proposed location for the new bridge, which is used when the river is at such a stage as to prevent passing the suspension bridge.

Below the site of the proposed bridge there is now no practicable landing, and if such landing could be prepared it is claimed that it would be inconvenient, expensive, and, in fact, impracticable for the business of freight and passenger steamboats. The boats which navigate the Ohio River above Cincinnati are generally of a smaller class and usually do not pass under the suspension bridge.

A bridge is a permanent structure which must always be, to a greater or less extent, an obstruction to the free and untrammeled use of the

river. The interests involved are therefore not only those of to-day, but those which may grow up in the future. There is no question of the fact that the present interests requiring the construction of a bridge across the river are large and should receive proper consideration, but it is believed that such interests received fair consideration when the general bridge law was enacted; and in the interest of all parties who are now or may hereafter be concerned in the bridging of the Ohio River, it would seem that the general law should be enforced until it can be shown that its provisions are not equitable, and then it should be repealed or changed for the good of the general public.

A careful reconsideration of the question of the authority conferred on the Secretary of War by the act of February 14, 1883, to make changes in a bridge where the site is unfavorable, convinces the Board that a channel-span of more than 500 feet may be insisted upon.

CONCLUSIONS AND RECOMMENDATIONS.

The Board is of the opinion that the location selected by the "Kentucky and Ohio Bridge Company" for a bridge over the Ohio between Covington and Cincinnati is an unfavorable one, and that the plans presented for consideration should not receive the approval of the Secretary of War.

The Board knows of no circumstances connected with the construction of a bridge in the proposed location which warrant an exercise of the discretion given by the special act or any modification of the general bridge law tending to lessen its requirements.

If the proposed site is to be retained, one channel-span should, in the interest of the coal traffic, be provided giving a clear width of waterway at all stages of not less than 550 feet.

In the event of the presentation of plans for a bridge on the proposed site with a channel-span giving a clear width of water-way at all stages of not less than 550 feet and leaving to the bridge company the alternative of a pivot-draw in a span next to main span in conformity with the general law, or, in lieu of the pivot-span, a high span giving head room of at least 53 feet at high water, it is recommended such plans be approved. The Board requests that there be appended to this report a copy of the letter of Col. Wm. E. Merrill, of February 20, 1882,* printed in Report No. 814, House of Representatives, Forty-seventh Congress, first session. This letter contains much important information and statistics and had very great weight in fixing the height for bridges over the Ohio River under existing laws. The letter is especially valuable, but the whole of the document might with propriety be made an appendix to this report.

The following papers received by the Board are transmitted herewith:

Letter from John A. Wood & Son, of Pittsburgh, Pa., giving certain statistics as to amount of coal, etc., passing Cincinnati by river annually. Protest from the "Steamboat Officers' Protection Association," of Pittsburgh, against the construction of the proposed bridge.

Letters received through Mr. Randolph, chief engineer of the Bridge Company; from C. C. Waite and M. Ingalls, of the Cincinnati, Hamilton and Dayton, and Cincinnati, Indianapolis, St. Louis and Chicago Railway Companies; from Capt. W. Honshell; and from A. Petry, giving certain gauge-readings.

Written communications giving statistics are expected from the Pittsburgh Coal Exchange and Cincinnati Board of Trade, and will

*Report of Colonel Merrill's appended. For the report of the Committee on Commerce, see Annual Report of the Chief of Engineers for 1882, pages 2001–2010.

be forwarded as soon as received. This information was before the Board, but not in such form as to admit of being sent with report. It has not been deemed proper to delay the report for the papers expected, but they should properly be considered in connection with the question at issue.

Respectfully submitted.

WM. P. CRAIGHILL,
Lieut. Col. of Engineers.
AMOS STICKNEY,
Major of Engineers.
A. MACKENZIE,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, February 20, 1882.

GENERAL: I have the honor to submit the following report upon House bill No. 204, Forty-seventh Congress, first session, a copy of which was received at this office with department letter of the 2d instant.

The law that now governs the construction of bridges across the Ohio River was passed December 17, 1872.

The proposed act is supplementary and additional. It does not abolish the existing law, but merely adds to the present authorized structures two other styles of bridges, leaving to bridge-builders the privilege of choosing from among all the legalized styles that particular one which may best suit their convenience.

To assist in comprehending the provisions of the existing bridge law, and the additions included in the proposed amendatory act, I have prepared the following tabular statement.

It will be observed that the proposed act affects only such bridges as are now required to have high-water draws, which are those which cross the Ohio below the Cincinnati Suspension Bridge.

Styles of bridge authorized by act of December 17, 1872.					Additional styles proposed by amendatory act (high-water draw omitted).				
High bridges.					High bridge.			Low bridge.	
Location of bridge.	Width of water-way under channel-span.	Clear height. Above low water.	Clear height. Above high water.	High-water draw.	Minimum width of water-way under each span.	Height under channel span. Above low water.	Height under channel span. Above high water.	Clear opening of draw-span.	Height of bridge above high water.
	Ft.	*Ft.*	*Ft.*		*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
Pittsburgh to mouth of Big Sandy River.	400	90	40	None.	(*)	....	....	....	....
Mouth of Big Sandy River to Cincinnati Suspension Bridge.	400	100	40	None.	(*)	....	....	....	....
Below Cincinnati Suspension Bridge.	400	100	40	Two clear openings of 160 feet each.	†400	107	62	400	10

* No change in present law. † All spans to be through spans.

The question of the kind of bridge that should be erected across the Ohio River has two sides, the commercial and the engineering, and an intelligent discussion of the proposed law requires that both of these sides should be fairly presented. Immediately, therefore, upon the receipt of the bill in question, I sent copies of the same to all the representative commercial bodies of the Ohio Valley, requesting an expression

of opinion as to its provisions. I inclose herewith the replies received from the joint committee of the Chamber of Commerce and the Coal Exchange of Pittsburgh, from the Board of Trade of Gallipolis, from the Board of Trade of Cincinnati (concurred in by the Chamber of Commerce), and from the Louisville Board of Trade. The conclusions of these bodies may be concisely stated as follows:

The river interests of Pittsburgh state that no form of low draw-bridge is admissible under any circumstances. They recommend that the present law be so changed as to require that all bridges shall have *two* clear openings of 500 feet each, and a height above high water of 45 feet.

The river interests of Gallipolis wholly condemn low draw-bridges, but approve of the high bridge with 400-foot spans.

The river interests of Cincinnati likewise unqualifiedly condemn the second alternative in the proposed act, the low draw-bridge, but approve the proposition to increase the height of bridges and to abandon the high-water draw, provided the channel-opening be increased to 500 feet. They think, however, that a height of 62 feet above high water is unnecessary, and that a height of 53 feet would answer every need of navigation.

The river interests of Louisville object to any change in the present law, and specially condemn the low draw-bridge.

Before proceeding further it is adviseable to give a brief description of the leading kinds of navigation on the Ohio, as the adaptability of any style of bridge to the wants of navigation can not be determined until the characteristics of that navigation are understood.

Probably the most important river interest on the Ohio is the transportation of coal. Although the total value of the coal transported is small as compared with that of other shipments by river, this interest exceeds all others in importance, as cheap fuel is the foundation of all manufacturing prosperity, and the manufacturing interests of the Ohio Valley, which are already very large and are daily becoming more important, are wholly dependent upon the river for fuel. There are numerous railroads, in all directions, that pass through rich coal basins, but they never attempt to supply coal except during the occasional coal famines which succeed long periods of low water. They find it impossible to compete with the river during a good boating season, and hence have not provided themselves with facilities for handling coal. It is, therefore, of national importance that no avoidable obstacle should be placed in the way of the cheap transportation of coal by water.

The method of bringing coal from the mines on the Monongahela, the great Kanawha, and the Ohio itself, is to load the coal in barges, collect these barges into fleets, and push them down the river by large tow-boats. Above Louisville the fleets are usually composed of from six to sixteen barges, covering an area of from one-half an acre to an acre and one third, with a width of from 75 to 100 feet, and a length of from 400 to 600 feet. An average fleet of ten barges brings to market 120,000 bushels or 4,500 tons of coal. Below Louisville the river is wider, and there are as yet no bridges; it is therefore the rule to double the size of the fleets which carry fuel from Louisville to New Orleans and other cities and towns on the Lower Mississippi.

It is for this commerce that wide spans are needed. No special provision for height is required, as tow-boats are always lower than first-class passenger steam-boats. Whatever height will suit the latter will necessarily suit the former; and, conversely, the widths necessary for coal fleets will more than suffice for passenger and freight steamers.

It is claimed that for safety coal fleets should have channel spans of 500 feet, and in this claim I fully agree. The necessity for such an increase in width on the river below Louisville, where coal tows are doubled, is too apparent to need much discussion. No bridge has thus far been built on this part of the river, although one has been authorized, and is now under construction, at Henderson. The projectors of this bridge, at the urgent request of the representatives of the Pittsburgh Coal Exchange, voluntarily agreed to increase the channel span so as to give a clear opening of 500 feet.

Above Louisville the matter rests on different grounds. There is no difficulty for an upper river coal fleet to run during daylight the channel-span of any properly located bridge giving a clear opening of 400 feet, but it is not at all an easy matter to do so during the night. Under the present distribution of bridges across the upper Ohio, coal shippers select such hours of starting and such rates of travel as will enable them to reach each bridge during daylight. A bridge has, however, just been authorized at the mouth of the Great Kanawha, which is at such a distance from the next bridge above (that at Parkersburg) that it will be almost impossible to avoid passing it at night unless the fleet is stopped to await daylight. But it is not an easy matter to land a coal fleet at any time, and suitable landings are not always available. Even should it be found practicable to make a landing the result would be a loss of twelve hours in passing the bridge. It is possible that the running of bridges at night may be facilitated by additional lights on the bridge and on the banks, but, even at the best, any bridge built in a section of the river that is now habitually run

at night must either cause an expensive increase in the length of the voyage or extra hazard to life and property. Even with the present system of daylight running there is no bridge over the Ohio (except the two suspension bridges) which has not a record of boats lost against its piers, and in a few cases there has been loss of life. It must not be forgotten that every additional bridge is an *additional* and *independent* obstruction of an existing navigation of immense value to the communities which are supplied by it with cheap fuel, and hence the importance of adding as little as possible to a burden already oppressive.

For this reason I am decidedly of the opinion that the channel-spans of all future bridges over the Ohio River should give clear openings of 500 feet; but, on the other hand, I think *one* such span is enough, provided the whole bridge is built as a "through" bridge. The effect of such a law on the cost of bridges built under it will be discussed further on.

Upon the question of *height* the steamboat men of Cincinnati and Louisville are the best authorities, as Pittsburgh tow-boats are always lower than the packets which ply between Cincinnati and New Orleans. When preparing the first draught of the present bridge law, the Board of Engineers recognized the fact that the heights prescribed were insufficient for the large steam-boats which run on the Lower Ohio and the Lower Mississippi, and, in order not to stop such boats during high waters, they introduced the provision that the bridges below Cincinnati should also be provided with a high water draw. There was no necessity for such a provision above Cincinnati, as the boats running on that part of the river are much lower than those which run to New Orleans.

While this high-water draw is a necessity in bridges of the present legal height above high water, it is undeniable that a draw-span is a nuisance and a danger both to the railroads that must build and operate it and to the steam-boats which must pass through it. The draw of the Cincinnati Southern Railway bridge is well located, and is equipped with a steam engine for handling, and yet on several occasions passenger packets have barely escaped serious accidents in passing it. Any increase in the height of bridge that will make draws unnecessary will be a boon to both parties, but the increase should not be so great as to prevent the construction of the bridge.

All Ohio River steam-boats are now equipped with apparatus for lowering their chimneys so that their tops shall come below the tops of their pilot-houses, and if sufficient room be given to pass the latter it will be unnecessary to have a draw.

The following table, originally prepared in November, 1877, for use in discussing the proposed bridge at Evansville, gives the height of the pilot-houses of the largest steam-boats at that time running between Cincinnati and New Orleans:

	Charles Morgan.	Robert Mitchell.	Thomas Sherlock.	Thompson Dean.
Apex of roof .... feet.	53.09	53.82	55.10	61.67
Railing on top .... do.	55.29	....	57.35	....
Corner posts on top .... do.	55.79	55.17	57.35	....
Top of fancy work .... do.	55.52	59.47	59.15	66.67
Top of whistle .... do.	60.25	50.96	62.55	69.17
Top of stove-pipe .... do.	50.54	55.40	60.30	67.67

All the above measurements are from the light-draught and water-line, and will be lessened in proportion to the load which the boat may carry. The first three boats were measured here by one of my assistants, and the measurements of the *Thompson Dean* were furnished by Major Howell, Corps of Engineers, stationed in New Orleans. The only measures given in the above table which need be considered are those in the first line, as the whole of the fancy work of the pilot-houses can be omitted if necessary, and the whistles and stove-pipes can either be cut down or lowered like the chimneys.

The first three boats are among the largest for which provision need be made. The *Thompson Dean* has not been to Cincinnati for many years, and she will probably end her days in the Lower Mississippi. The extra height of her pilot-house is unnecessary, and need not be duplicated in future boats of her class.

It is not likely that any large steam-boat would pass an Ohio River bridge during a great flood with a less immersion of her light-draught water-line than 2 feet, and hence we may conclude that a height above high water of 53 feet would answer every necessary requirement of navigation, even in extreme floods, and make the draw unnecessary. It is evident that the height proposed in the amendatory act, 62 feet above high water, is at least 9 feet higher than need be.

The provision of 107 feet above low water is superfluous, and should be omitted altogether. If bridges are so arranged that boats can pass under them at all times,

even in extreme high water, it is evidently unnecessary to make any provision at all for low water.

The following table gives the readings of high and low water, and the maximnm oscillation at certain points witnin the region covered by the proposed amendatory act:

	High water.		Low water.		Oscillation.
	Gauge-reading.	Year.	Gauge-reading.	Year.	
	Feet.		*Feet.*		*Feet.*
Cincinnati	64.00	1832	1.50	....	62.50
Louisville, head of falls	40.76	1832	1.09	1856	39.66
Louisville, foot of falls	67.50	1832	1.00	1856	66.50
Evansville	46.29	1832	0	1870	46.29
Paducah	53.00	1867	0	1857	53.00
Cairo	50.97	1867	—1.00	1871	51.97

If bridges are built 107 feet above low water and 62 feet above high water, it is evident that the latter measure will include the former at all points where the oscillation exceeds 45 feet. The only case of those given above in which the height above low water would control is at the head of the falls.

If the proposed reduction to 53 feet above high water be adopted, the following would be the corresponding heights above low water of bridges built at the places named in the table:

	Above high water.	Above low water.
Cincinnati	53.00	115.50
Louisville, head of falls	53.00	92.66
Louisville, foot of falls	53.00	119.50
Evansville	53.00	99.29
Paducah	53.00	106.00
Cairo	53.00	104.97

This table shows that if bridges were authorized to dispense with draws when raised to a height of 53 feet above high water, this alternative method of construction would probably be adopted at all the points named, except at Cincinnati and at the foot of the falls, at both of which points the oscillation is excessive. There would be nothing to prevent the adoption even at these localities of the high bridge without draw, but the height required would be so great and the length of the approaches so much increased that it is altogether probable that bridge-builders would prefer to build under the present law.

INCREASED COST OF 500-FOOT SPANS.

Thus far this report has considered only the necessities of navigation. Justice requires that the great land transportation routes, for whose use bridges are built, should not be forced into unreasonable and excessive expenditures, and the proposed increase in channel water-way should, therefore, be examined from their stand-point.

In what precedes, while I have chiefly discussed the question of an *alterative* method of construction, which need not be adopted unless bridge companies find it for their interest to do so, I have also advocated a change both in the present law and in the proposed amendatory law, so that *all* future bridges over the Ohio shall have channel-spans giving a clear water-way of 500 feet. My reasons for this proposed increase have been stated, and it only remains to examine into the question of the effect of such an increase upon the cost of bridges. No question of practicability is involved, as one of the latest bridges over the Ohio, that at Cincinnati, built in 1877 by the Cincinnati Southern Railway, has such a channel-span, and the bridge just authorized at Henderson is also to have a 500-foot span, this concession having been voluntarily made at the request of coal shippers.

As the only truss bridge thus far built in the United States with a 500-foot waterway (520-foot span) is the one at this city, just mentioned, I applied to the chief engineer of that railroad for an estimate of the *additional* cost of that span, taking into consideration the corresponding reduction in the length of the adjacent spans. The calculation is necessarily only approximate, since the cost of the bridge, as originally

designed with a 400-foot span, could be determined only by estimate. He concludes that the extra cost was $39,891. As the price of bridge work has, however, increased since the building of this bridge from 7 cents to about 9 cents per pound, the present cost of a like change would be $51,289.

In round numbers we may assume that bridges over the Ohio with their approaches vary in cost from $800,000 to $1,500,000, depending upon the locality and upon the prevailing prices of labor and material at the time of construction. The additional cost of a 500-foot water-way is therefore from 3 per cent. to 6 per cent. of the cost of the bridge, which is certainly very small in view of the great increase of safety to navigation which will result. It is therefore evident that a law increasing channel openings to 500 feet could not be considered as oppressive.

In the bill introduced by Mr. Townshend, it is provided that *all* of the spans of the high bridge shall have 400 feet of clear width of water-way. In my judgment, 400 feet is not enough for the channel-span, and is unnecessary in the side-spans. One well-located channel-span of 500 feet water-way will amply provide for all descending navigation, while the necessities of economical construction will make all the side spans wide enough for all ascending navigation without the interference of law.

DEFECTS IN THE PRESENT BRIDGE LAW.

If any additional legislation is to be had on Ohio River bridges, advantage should be taken of the opportunity to remove whatever defects have been discovered in the present law during the ten years of its existence. Under this law have been built the railroad bridges at Beaver, Pa., and at Cincinnati, Ohio (Cincinnati Southern); and the bridges at Point Pleasant, W. Va., at New Albany, Ind., and at Henderson, Ky., have been authorized. All of these bridges have been reported upon by Boards of Engineers, and in every case I have been a member of such Boards.

The following defects have been discovered:

1. *All spans should be "through" spans.*—The present law requires only the channel-span to be a "through" span. If all of the spans were "through" spans, ascending steam-boats and tows could pass under any span and thus save delay and danger of collision in case descending boats were approaching the channel-span. All of the spans of the Cincinnati Southern Bridge were voluntarily made "through" spans, much to the advantage of navigation; and there is no reason why other bridges should not be similarly constructed. The difference in cost is very little, while the difference in adaptedness to navigation is very great.

2. *Height should be measured to lowest part of the span.*—The present law requires that measurements be made to the "bottom chord of the bridge." As most bridges are now built with their road-way bearers suspended below the bottom chord, the wording should be changed as indicated, in order that the full height contemplated by the law may be preserved.

3. *Rest-piers for draw when open.*—Bridges with draws should be required to have protection or rest-piers above the pivot-piers, and the space between these two should be filled with crib-work or with float, so that boats may enter the draw with safety. This arrangement has been made at every bridge over the Upper Mississippi, and was prescribed for the Cincinnati Southern Railroad Bridge by the Board of Engineers who reported upon it. The Secretary of War, however, did not insist on this protection-pier, as he was evidently uncertain as to his right to do so, although he warned the trustees that if he omitted it the courts of law might enforce its construction. This pier was omitted, and, as a consequence, the passage of this draw is considered by all boatmen as extra hazardous, and is greatly dreaded. According to general engineering practice such piers are essential and necessary parts of every draw-bridge; and as their existence is necessary to the safe passage of the draw their construction should be enforced by law.

4. *Unobstructed access to draw.*—It is also essential that the approaches to the draw-span should not be obstructed by boats or fleets moored to the banks in the near vicinity either above or below. The passage of the draw-span of the Cincinnati Southern is seriously embarrassed by a large fleet of coal-barges which is habitually moored just below this bridge, completely closing one of the draw-spans and jeopardizing the use of the other. As the construction of the bridge has forced steam-boats to go to this shore, the owners of the bridge should have extinguished the right of private wharfage along a distance of at least two boat-lengths (say 700 feet) above and below, so that steam-boat men would not have the fear of collision, in addition to the natural and inevitable dangers due to the swift currents of high water.

5. *Additional safeguards at objectionable sites.*—It sometimes happens that the necessities of railroads require them to bridge the river at places where the currents are unusually variable and the natural difficulties of navigation are very great. In such cases the safety of navigation may require the Secretary of War to refuse his approval of the construction of the bridge unless the dangers of the proposed structure are overcome by increasing the width of the channel-span, or by building auxiliary works to protect navigation from cross-currents or similar dangers. This was notably

the case at the Beaver Bridge, and the Board of Engineers, rather than wholly condemn the bridge, recommended that the water-way be increased, and that a guiding like be built above the left-hand channel pier. The bridge company accepted this solution of the problem, and built the bridge with the increased water-way, but *without the guiding dike*, which latter they have practically refused to construct.

The Secretary of War referred the question to the Judge-Advocate-General, and the latter gave the opinion that the Secretary had no power to compel the bridge company to build this dike. The whole matter was then referred to Congress, but no action has thus far been taken in regard to it. [Senate Ex. Doc. 28, Forty-sixth Congress, second session, and Report of Chief of Engineers, 1880, page 1849.] I consider it very important that the powers of the Secretary of War in such matters should be clearly defined, although, in case the channel-spans of bridges should be increased to 500 feet, it is not likely that a similar controversy will again occur.

AMENDATORY ACT PROPOSED.

To facilitate the consideration of this important matter I have taken the liberty of preparing the accompanying supplementary act, which will, in my judgment, fully meet the necessities of navigation on the Ohio River, without imposing unnecessary burdens upon land transportion across that river.

Respectfully submitted.

WILLIAM E. MERRILL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

LETTER FROM ATTORNEY OF THE COVINGTON AND CINCINNATI ELEVATED RAILWAY, TRANSFER AND BRIDGE COMPANY.

WASHINGTON, D. C., *March* 9, 1887.

DEAR SIR: Referring to your decision that the bridge to be erected across the Ohio River between Covington and Cincinnati, under the act of Congress approved May 20, 1886, should have a height of 43 feet above high-water mark, and should have a central span of 550 feet, we respectfully submit herewith, in duplicate, the plans for such bridge in conformity with such decision; and requesting your formal approval thereof, we remain,

Yours, very respectfully,
COVINGTON AND CINCINNATI ELEVATED RAILWAY,
TRANSFER AND BRIDGE COMPANY,
By CHARLES H. TWEED,
Attorney.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.

[First indorsement.]

WAR DEPARTMENT, *March* 10, 1887.

Respectfully referred to the Acting Judge-Advocate-General to prepare the proper formal license in this case.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

[Second indorsement.]

WAR DEPARTMENT,
JUDGE-ADVOCATE-GENERAL'S OFFICE,
Washington, D. C., March 11, 1887.

Respectfully returned to the Secretary of War, with papers prepared as directed.

G. NORMAN LEIBER,
Acting Judge-Advocate-General.

[Third indorsement.]

WAR DEPARTMENT, *March* 19, 1887.

Respectfully referred to the Chief of Engineers to file the accompanying duplicate copy of the approved plans in his office. The original has this day been sent to the address of Mr. Charles H. Tweed, attorney for the Covington and Cincinnati Elevated Railway, Transfer and Bridge Company, Mills Building, New York City.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

X X 2.

REPORT OF BOARD OF ENGINEERS ON PAPERS OF STATEN ISLAND RAPID TRANSIT COMPANY, SUBMITTING PLANS AND LOCATION FOR BRIDGE ACROSS ARTHUR KILL, STATEN ISLAND SOUND.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS
AND FOR RIVER AND HARBOR IMPROVEMENTS,
New York, September 2, 1886.

The Board of Engineers has the honor to acknowledge the receipt of the papers sent by T. M. King, vice-president and managing director of the Staten Island Rapid Transit Company, on July 12, 1886, to the Secretary of War, submittting location and plan for a bridge across the Arthur Kill, with an indorsement from the Secretary of War requiring a report thereon.

On July 26, 1886, the Secretary of War, by an indorsement on this letter, directed the Board as follows:

> The matter is to be considered as if the Secretary of War had full power to change plans or substitute others.

This indorsement, therefore, requires from the Board a report as to what is a proper and admissible bridge across this water way.

The Board inspected the Arthur Kill, examined the Raritan Bridge, and caused a survey to be made of Buckwheat Island. A public meeting was held, at which representatives of the interests involved were invited to express their views at length, either orally or in writing.

The name Arthur Kill is applied to the water-way which on the west side of Staten Island separates it from New Jersey. With one marked exception it is nearly straight, and has a length of 12 miles, a width varying from about 600 feet to about 3,500 feet, and a navigable depth at mean low water of 13 feet, or of 18 feet at high water. There are no bridges across it.

The freight passing through this water-way is (1) that which is derived from the Delaware and Raritan Canal, and according to the affidavits of R. S. Murphy, collector of Delaware and Raritan Canal, herewith, was, for 1885, 1,014,103 tons; (2) that from Perth Amboy, which, according to the affidavit of I. L. Fisher, president of Steamer and Sailing Vessels Owners' Association, is 95 per cent. of 2,169,950 tons, or 2,061,452 tons, of which 75 or 80 per cent. is coal from the Lehigh Valley Railroad; (3) from the affidavit of A. C. Davis, terminal agent at South Amboy, it appears that 2,125,464 tons of freight were shipped to and from that point in 1885. If 90 per cent. of this went through Arthur Kill, it would be 1,912,918 tons. If the freight derived from the Raritan River which does not come through the Delaware and Raritan Canal be taken

as 400,000 tons (see Chief of Engineers' Report, 1884, page 756), the aggregate of the items will be 5,418,473 tons, and when the scattered manufactures and industries not included in the above large amounts are added the tons of freight to pass the site of the proposed bridge will approach 5,750,000 or 6,000,000 tons annually. These are actual tons of freight, and are not the mere tonnage of vessels carrying it, irrespective of whether the vessel is loaded or empty. It exceeds the tonnage of foreign commerce cleared from New York for 1885.

The tonnage passing through Detroit River in 1884 (Report of Chief of Engineers, 1885, page 2169) was 19,645,271 tons. This registered tonnage should be reduced 25 or 50 per cent. to give actual freight.

The total tonnage of boats and vessels passing over the Falls of the Ohio at Louisville, Ky., in the fiscal year 1884–'85 was 256,015 tons; through canal, 1,217,231 tons; total, 1,473,246 tons. (Report Chief of Engineers, 1885, pages 1809, 1810.)

The freight received and shipped at Saint Louis in the year 1884–'85 to and from points on the Upper Mississippi was 281,355 tons. (Chief of Engineers' Report, 1885, page 1665.)

It is thus seen that so far as tonnage is concerned this is one of the great water-ways of this country, and indeed of the world.

Of the vast amount of freight annually passing through Arthur Kill probably nine-tenths is in tows. These tows contain a varying number of boats, barges, lighters, or other vessels, sometimes reaching seventy, according to Mr. Chase's affidavit.

The large tows are usually made up with five vessels abreast and are about eight vessels long. The dimensions of such a solid tow are 100 to 125 feet in width by about 800 feet long, carrying 6,000 or 7,000 tons of freight. When to the length of the tow proper is added the length of the towing line and of the tug, a total length of about 1,500 feet results. Under the plan submitted by the Staten Island Rapid Transit Company, such masses of vessels, 100 feet wide and 800 feet long, and towed in the way described, are to pass through a clear opening between piers about 200 feet wide. The experience at the draw at the mouth of the Raritan River, through which but about one-third as much freight passes as through the Arthur Kill, and which has 207 feet draw-openings, is the best guide in judging whether such a bridge across the Arthur Kill will be an obstruction to navigation. It appears from evidence given to the Board that the tows which come down the Raritan River are but about one-third the size of those which are taken through the Arthur Kill; that these small tows anchor if necessary and wait for slack water to safely pass through the Raritan River draw. In spite of precautions, it seems from the affidavit of Mr. Chase that this draw is a serious obstruction to navigation, and has caused considerable losses from delays and collisions. In one of the latter twenty-one boats were injured and 1,000 tons of freight were sunk.

The tows to go north through the Arthur Kill are made up at Perth Amboy or South Amboy, and start at the beginning of flood tide so as to reach New York on that tide. They pass the proposed site of the bridge while the tide is running flood and when any collision would produce great damage. The tows are much larger than those passing through the Raritan draw, and it is impracticable for these large tows to anchor as the smaller ones do at the Raritan draw. Hence, in the opinion of the Board, if a bridge were constructed as proposed with a pier in the middle of the Kill it would necessitate a large reduction in the size of tows and the consequent increase in the cost of transportation.

The water-way is at present a most important one, and will be of still greater importance in the future. The removal of a natural obstruction so serious as a pier in the middle of the stream would be urgently and rightly demanded even at great cost. The obstruction is not there now, and it should not be placed there to the injury of navigation, in order to save a few hundred thousand dollars to the railroad company.

The bridge proposed by the Staten Island Rapid Transit Company is located about 2,900 feet below the mouth of the Elizabeth River, where the Arthur Kill is about 750 feet wide. Starting from the Staten Island side the intervals between the axes of its piers are, in order, 150 feet, 250 feet, 250 feet, 150 feet; the large spans being draw-spans, giving between the pier-fenders clear openings of 200 feet. The height of the lowest part of the superstruction is 34 feet 8 inches above mean low water.

The main and sufficient objection to this plan is that it places a masonry pier in the middle of a water-way that is none too wide now, and that it will require, after its construction, towing to be done in smaller tows at greater expense.

The following table, compiled from data furnished by the railroad company, will give an idea of the heights of smoke-stacks at present passing through the Arthur Kill:

The heights marked (*) are measured; the others were approximately determined as the vessels passed. The observations extended from August 7 to 21, 1886, and covered about 12 hours daily. Only steam vessels whose names were reported are included in this table; many others passed. It appears that of these 411 passages 57 per cent. would pass under a clear headway of 35 feet, 71 per cent. under 40 feet, and 81 per cent. under 50 feet.

Name.	Height of smoke-stack.	Passed bridge site number of times.	Name.	Height of smoke-stack.	Passed bridge site number of times.
	Feet.			*Feet.*	
New Brunswick	*57	28	Chester	26	2
Minnie Cornell	*57	23	Howard	25	3
Fred. de Barry	50	2	R. F. Cahill	*30	4
Henry E. Bishop	50	8	E. Meyers	24	4
Sylvester	*50	12	Tacony	25	1
Florence	50	2	Harry	30	6
Patrol	50	1	J. W. Boyle	25	1
Pomona	50	4	Hessie	20	1
Blackbird	50	2	Crystal Stream	40	6
Blue Bonnet	45	5	Eaglet	40	2
Martha Stevens	45	1	Annie	40	2
B. Lockhart	42	3	Amboy	40	1
M. Brazos	35	3	Fannie Cadwalader	40	3
Mayflower	35	2	Vesper	*41	2
Octorora	35	2	R. A. Packer	†*35	4
Clara	35	18	Raritan	*47	8
Willie	35	5	Anne Eliza	40	1
Milzingah	†33	16	Baltimore	40	1
Franklyn	35	8	General Sedgwick	45	1
J. W. Garrett	35	2	J. H. Mason	30	1
Wm. Vanderbilt	35	2	Coffin	22	1
Mabel	35	2	Titan	30	4
Reliance	38	2	Alice E. Crew	21	2
I. L. Sturdevant	*27	16	Gov. H. M. Hoyt	30	5
Annie Williams	*20	22	Hackensack	*30	15
Delaware	27	7	Fannie	25	3
Seabord	*33	1	May Clinton	22	2
Advance	*27	37	Alfred and Edwin	27	4

Name.	Height of smoke-stack.	Passed bridge site number of times.	Name.	Height of smoke-stack.	Passed bridge site number of times.
	Feet.			*Feet.*	
Chas. Allen	22	1	Niagara	25	1
Albert Robinson	22	1	Aries	25	1
L. Flannagan	25	2	C. Dean	30	2
Joseph Stickney	*34	3	W. Murtach	25	4
D. C. Cox	*29	6	W. L. McAldine	28	1
J. T. Stranahan	*33	2	Gen. A. E. Burnside	30	2
Zouave	*24	1	E. G. Burgess	25	1
R. L. Meyer	27	1	Defiance	28	1
Mirage	*24	2	Francis Jackson	*32	1
Gertrude	30	2	W. Standart	30	1
F. W. Braune	33	1	J. B. King	25	2
J. F. Fisher	*28	1	Roslyn	25	4
F. P. Skeer	28	1	J. H. Smith	28	2
Ant	22	5	Agnes	20	5
Missouri	20	1	O. K. Neal	25	2
Annie M. Bauer	*24	8	Phenix	25	4
A. Demerest	25	1	Elizabeth	20	1
R. H. Williams, jr	25	6	Admiral	25	2
G. W. Wright	25	2	F. Linderman	*24	2
Jennie	20	3	Brons	25	1
Vineland	25	4	E. A. Packer	21	1

The following information as to heights of masts of sail and tow barges is received from Mr. Harrison. Those passing from Philadelphia to New York by the Delaware and Raritan Canal average about 91 feet; those of the Bee Line Transportation Company average about 60 feet. Further details are contained in his appended letter.

A bridge across the Arthur Kill which shall not interfere seriously with navigation must give a clear water-way in the channel of the stream as wide as practicable, in order to permit the passage of large tows safely and freely. Where such tows are liable to strike the piers, suitable guides and fenders should be supplied. It should be high enough above the water-surface to allow the great mass of the commerce to go under this wide span without inconvenience. For masted vessels it should have a draw.

The Board therefore recommends to the Secretary of War a bridge at the site proposed by the Staten Island Rapid Transit Company, the channel-face of whose east pier shall be on the Staten Island bulkhead or shore line (these coinciding at the site) and whose channel-span shall give a clear opening of 450 feet, whose span next west shall be a draw-span giving 125 feet clear opening; the lowest parts of these spans being 50 feet above mean high water. The foundations of the piers should be so arranged as to admit future deepening of the Kill to 20 feet. Such a bridge will be an obstruction and an inconvenience, but will not in any serious degree increase the cost of transportation. It involves some increases of cost to the railroad company, but no more than it should bear, rather than infringe on the pre-existing rights of navigation.

In the opinion of the Board, no plans for a bridge with a pier in or near the middle of the channel should be approved.

Buckwheat Island has been proposed as a site for the bridge. The objections to it are that on one side of the island the channel has but 6 feet of water, and on the other the channel is narrower than at the site

proposed by the Staten Island Rapid Transit Company, so that the draw-bridge would be impracticable.

Respectfully submitted.

J. C. DUANE,
Col. of Engineers, and Bvt. Brig. Gen.
HENRY L. ABBOT,
Lt. Col. of Engineers, Bvt. Brig. Gen.
C. B. COMSTOCK,
Lt. Col. of Engineers, Bvt. Brig. Gen.
D. C. HOUSTON,
Lt. Col. of Engineers, Bvt. Colonel.
WALTER MCFARLAND,
Lt. Col. of Engineers.

The Board desires to append to its report the following documents received at the meeting or otherwise, of which the first six should be printed:

*1. A memorandum on Arthur Kill Bridge, submitted by J. R. Cowen, general counsel of Baltimore and Ohio Railroad.
*2. Affidavits of Daniel C. Chase and others in the interest of navigation.
*3. Abstract of observations upon the passage of vessels through Arthur Kill, August 7 to August 21, 1886, by Charles Ackenheil, chief engineer, Staten Island Railroad.
*4. Statement affecting the foregoing, by John McG. Sterritt.
*5. Letter of E. W. Harrison, of August 11, 1886.
*6. Affidavit of John P. Arnold as to number of vessels passing site of proposed bridge during about six days in July and August, 1886.
*7. Survey at Buckwheat Island by Lieutenant Derby.
*8. Map of northern portion of Arthur Kill, 1886, by E. W. Harrison.
*9. Map showing course of vessels in Arthur Kill, by Charles Achenheil.

[Indorsement on the foregoing letter.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
October 5, 1886.

Respectfully submitted to the Secretary of War, with accompanying papers herein designated as appended, together with previous papers in this case. The Board of Engineers, in compliance with instructions from the War Department of July 26, 1886, reports as to what would be a proper and advisable bridge across the Staten Island Sound, known as Arthur Kill, and is of opinion that no plan for a bridge with a pier in or near the middle of the channel should be approved, and further recommends, for reasons given, a bridge at the site proposed by the Staten Island Rapid Transit Railroad Company, the channel face of whose east pier shall be on the Staten Island bulkhead or shore-line, and whose channel span shall give a clear opening of 450 feet, and whose span next west shall be a draw-span giving 125 feet clear opening; the lowest part of these spans to be 50 feet above mean high water. The foundations of the piers should be so arranged as to admit of future deepening of the Kill to 20 feet.

Such a bridge, in the opinion of the Board, will be an obstruction and an inconvenience, but will not in any serious degree increase the cost of transportation. It involves increase of cost to the railroad company, but no more than it should bear rather than infringe on the pre-existing rights of navigation.

Since the conclusions of the Board, resulting from a careful consideration of the subject and of statements made, orally and in writing, by representatives of all interests involved regarding the requirements of the commerce and navigation of this important water-way, demand an

* Omitted; printed in Sen. Ex. Doc. No. 17, Forty-ninth Congress, second session.

entire modification of the plan for the proposed bridge submitted for approval by the Staten Island Rapid Transit Railroad Company, July 12, 1886, through Thomas M. King, vice-president and managing director, it is recommended that said plan be not approved.

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
In charge of Office.

INDORSEMENTS UPON WRAPPER INCLOSING, FROM J. F. EMMONS, PRESIDENT, MARCH 14, 1887, TRACINGS OF PLAN AND LOCATION OF PROPOSED BRIDGE; EVIDENCE OF INCORPORATION OF THE STATEN ISLAND RAPID TRANSIT RAILROAD COMPANY, AND ACCEPTANCE OF THE CONDITIONS IMPOSED BY THE ACT OF CONGRESS AUTHORIZING THE CONSTRUCTION OF THE BRIDGE.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS, U. S. ARMY,
March 19, 1887.

Respectfully returned to the Secretary of War through the Acting Judge-Advocate-General, U. S. Army.

The accompanying drawings, showing plan and location of the bridge proposed to be erected by the Rapid Transit Railroad Company under the provisions of "An act to authorize the construction of a bridge across the Staten Island Sound, known as Arthur Kill, and to establish the same as a post road," approved June 16, 1886, are believed to be in accordance with the requirements of the act, and are identical with those to which the Secretary has given a conditional approval.

The papers submitted by the president of the railroad company seem to meet the requirements of the rule of the Secretary of War dated July 31, 1886, and if this be the case there would appear to be no objection to the plans being finally approved.

J. C. DUANE,
Brig. Gen., Chief of Engineers.

[Second indorsement.]

WAR DEPARTMENT,
JUDGE-ADVOCATE-GENERAL'S OFFICE,
Washington, D. C., May 23, 1887.

Respectfully transmitted to the Secretary of War.

The evidence required by the rule of the War Department being complete, and the drawings showing plan and location of the bridge being, in the opinion of the Chief of Engineers, in accordance with the requirements of the act of June 16, 1886, the necessary papers have been drawn up, and are submitted herewith.

G. NORMAN LIEBER,
Acting Judge-Advocate General.

[Third indorsement.]

WAR DEPARTMENT, *March* 29, 1887.

Respectfully returned to the Chief of Engineers, to file in his office, the within-retained copy of instrument, the original having been transmitted to Mr. A. B. Boardman by War Department letter of the 26th instant.

By order of the Secretary of War.

SAM'L HODGKINS,
Acting Chief Clerk.

X X 3.

CHARACTER, ETC., OF BRIDGE TO BE CONSTRUCTED ACROSS THE MISSISSIPPI RIVER AT SAINT LOUIS, MISSOURI.

SAINT LOUIS, MO., *December* 31, 1886.

GENERAL: The Board of Engineers convened by Special Order No. 195, Headquarters Corps of Engineers, December 16, 1886, has the honor to submit the following report upon the question of the character of the bridge to be constructed at Saint Louis, Mo.

The Board met on December 28, and after reading the documents received from the Department and examining the records of the Engineer Office at Saint Louis relating to the subject, called a public meeting for 10 a. m. on December 29. This meeting was continued, with adjournments, until 2 p. m. of December 30, and was well attended. Several gentlemen interested for and against a low bridge freely expressed their views, which are briefly entered in the minutes of proceedings appended, marked A.

The desire for a new bridge at Saint Louis appeared to be unanimous among all classes represented, but a diversity of opinion existed as to its proper character. The promoters of the bills now before Congress authorizing a new bridge claimed that the grantees, being gentlemen of the highest personal character, selected by the Merchants' Exchange of Saint Louis, and above all suspicion of unworthy motives, should be allowed by Congress the privilege of deciding the question whether the bridge should be high or low. Their opponents, while freely admitting the high character of the grantees, claimed that Congress should not delegate its own prerogatives and establish a precedent which might be followed in the case of other cities lower on the river, to the great detriment of Saint Louis. The interests of the free navigation of the Mississippi should be jealously guarded by Congress itself, and should not be delegated to individuals liable to be blinded by local considerations.

As the instructions of the Board required it to report definitely the character of the bridge to be recommended, this question was waived, and the arguments for and against the low bridge were presented. In brief they may be thus stated:

ARGUMENTS FAVORING A LOW BRIDGE.

(1) The great necessity for a new bridge is to break the discrimination against Saint Louis now made by the freight tariff over the existing bridge, which is onerous and oppressive to the city. Hence, to favor competition, economy in construction and operating is of the first importance. The advocates of the low bridge claim that the difference in cost between the two kinds of structure is probably greatly in favor of a low bridge. They submit an opinion, without any detailed estimates, from Mr. E. L. Corthell, C. E., placing the cost of a low bridge at $1,500,000, and of a high bridge at 50 per cent. more, without including the increased cost of land approaches for a high bridge.

(2) It is necessary for a new bridge to connect with the present Union depot and the railroads running west, and this can only be done at moderate expense along the immediate bank of the river. A low bridge, in their opinion, would make a much shorter and cheaper connection possible.

(3) It was claimed that the cost of operating a low bridge would be less than that of a high bridge, on account of the avoidance of high grades and of long approaches.

(4) It was claimed that by the aid of a sheer boom a draw would be a less obstruction to navigation than a wide span.

ARGUMENTS FAVORING A HIGH BRIDGE.

The importance of a free, unobstructed navigation of the Lower Mississippi River is immense. It has been recognized by Congress by large annual appropriations. It alone affords protection against extortionate charges for transportation by corporations. A slight difference in cost of construction in the interest of a single locality should have no weight when considering a question of this national importance. A low bridge at Saint Louis would not only be detrimental to the commerce of the whole valley, but would also be a heavy burden upon important local interests of Saint Louis, especially the lumber and ice trades.

This broad view of the subject has always been advocated by the Merchants' Exchange of Saint Louis, until the new bridge project came under discussion, and is still held by prominent members. For example, the committee on river improvements, while unanimously favoring the construction of a new bridge, placed itself very recently, by a vote of seven out of ten members, strongly in opposition to a low bridge.

A low bridge at the site proposed for the new structure is objectionable for various reasons.

(1) The channel is constantly shifting, and a draw properly placed now might be entirely out of place in a few months, making the bridge impassable. Uncertain and costly works of channel regulation are therefore inseparable from a low bridge.

(2) The current below the mouth of the Missouri is about twice as strong as at the existing draw-bridges on the river above, and therefore such a bridge at Saint Louis would be a far greater obstruction than any now existing.

(3) The drift running out of the Missouri and past Saint Louis at every rise would render it impossible, without great danger to life and property, for a boat to control its tow by backing; but this is the only safe mode of passing a draw in a strong current. There being no drift on the Upper Mississippi, this difficulty does not affect existing draw-bridges above the mouth of the Missouri.

(4) The frequent passage of trains over a low bridge would cause delays intolerable, both to railroad and river interests, while a high bridge would leave each free from interruption. This point is elaborated from data furnished by General William Taussig, general manager of the Saint Louis Bridge and Tunnel Railroad, appended, marked G.

(5) The narrow width of the largest draw-spans (200 feet) is not sufficient to permit the passage of ordinary rafts and tows now reaching Saint Louis. There are no places for landing and breaking up below the mouth of the Missouri; hence, if a low bridge is built, the loss of time in making double trips, and consequently the increased expense in freight, will be great and will fall upon interests other than the bridge.

(6) The location chosen for the bridge would compel the removal of the present lumber yards at great expense to the owners, who claim that favorable locations above do not exist.

(7) The cost of constructing a high bridge is not necessarily much in excess of that of a low bridge. Colonel Flad, president of the Society

of Civil Engineers and president of the Board of Public Improvements of Saint Louis, presented approximate estimates, in which he placed this excess of cost at 10 per cent. He is exceptionally familiar with the locality from his connection with the construction of the Eads bridge, and he regards it essential to go down to solid rock for pier foundation, which would compel long spans for both types of bridge. The additional cost of higher piers would not be great, and the same may be said of the increased length of approaches and of the connection with the Union Depot. Adding the cost of continuous draw service and probable channel regulation for a low bridge, and the testimony before the Board made it a matter of doubt which would be in the end the more economical, a high bridge or a low bridge; the difference in any event would not be great.

CONCLUSIONS.

In view of all the data at our command, including the testimony taken before us, surveys and maps of the river, and the observations taken of its current, velocity, discharge, sediment, nature of bed and banks, and from our own personal knowledge and experience of the river itself and its commerce, the Board has arrived at the following conclusions:

(1) That while the present bridge across the Mississippi River has not yet been crowded to its full capacity, good reasons are shown for the building of a new bridge above the site of the present one.

(2) Full estimates and a definite location for the bridge were not presented, and its promoters stated that its character would largely depend upon these estimates. The Board believes that an exact or even fairly approximate cost of a new bridge, whether high or low, can not be determined without careful surveys, yet their relative cost can be approximately estimated. From evidence before it, the Board is decidedly of the opinion that the increased cost, if any, of a high bridge over that of a low bridge, including erection and operation, has not been shown to be so great as to warrant the conclusion that a low bridge is more desirable than a high bridge, even on the ground of cost alone.

(3) The Board has reason to believe that if a draw-bridge were built, it is probable that the channel might at times leave the draw-span and thus make the bridge impassable.

(4) The Board calls attention to the fact that an essential feature of the plan of a low bridge is that the channel should be held through the draw-spans. It is not certain that this can be done at all; certainly not without great cost. The matter is not alluded to in the bill itself, nor has it been provided for in any plan or estimate presented or discussed before the Board.

(5) The Board is decidedly of the opinion that a low bridge with a draw in it should not be authorized or allowed below the mouth of the Missouri River. Such a structure would be a serious and grave obstruction to navigation and a direct and oppressive tax upon all river interests. Justice to navigation interest requires that the proposed bridge should be no greater tax upon the commerce of the river than is absolutely necessary. Channel spans of 500 feet clear width, giving a clear headway of not less than 50 feet at high water, are the least dimensions that should be authorized, and with recent progress in engineering and the introduction of the cantilever principle it is not expecting too much to suggest that spans of even more than 500 feet may be found to be both practicable and economical.

(6) The Board desires to emphasize the difference of the Mississippi River above and below the mouth of the Missouri River. Above, it is a quiet river, comparatively free from sediment and drift; the oscillation between high and low water does not exceed about 22 feet. Although low bridges on such a stream are obstructions to navigation, they are not intolerably so. Below the mouth of the Missouri all this is changed. The rise and fall increases to 42 feet at Saint Louis and over 50 feet at Cairo; the current doubles in velocity, as shown in the table in our first day's proceedings; the volume of sediment is vastly increased; drift frequently runs; the bed is constantly shifting. In a word, the river entirely changes its character, and low bridges must be regarded as an intolerable nuisance to navigation interests.

The Ohio River, which in its lower course resembles the Lower Mississippi, is protected by a general bridge law forbidding the construction of low bridges, and, in the judgment of the Board, such a law, properly adapted to suit the requirements of the Mississippi below the mouth of the Missouri River, would be useful legislation, in view of the increasing demand for bridges on the Lower Mississippi.

HENRY L. ABBOT,
Colonel of Engineers,
Bvt. Brig. Gen., U. S. A.
A. MACKENZIE,
Major of Engineers.
A. M. MILLER,
Major, Corps of Engineers.
E. H. RUFFNER,
Captain of Engineers.

Brig. Gen. J. C. DUANE,
Chief of Engineers, U. S. A.

PROCEEDINGS OF BOARD.

SAINT LOUIS, MO., *December* 28, 1886.

Proceedings of a Board of Engineers convened by virtue of paragraph 3, Special Orders 195, Headquarters Corps of Engineers, dated Washington, D. C., December 16, 1886.

Special Orders No. 195.

HEADQUARTERS CORPS OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 16, 1886.

[Extract.]

* * * * * * *

(3) By direction of the Secretary of War a Board of Officers of the Corps of Engineers, consisting of Col. Henry L. Abbot, Maj. Alexander Mackenzie, Maj. Alexander M. Miller, Capt. Ernest H. Ruffner, will assemble at Saint Louis, Mo., upon the call of the senior member, at the earliest practicable day consistent with the other duties of the members, to investigate and report upon the character of the bridge to be constructed across the Mississippi River at that place.

The junior member of the Board will act as recorder.

Upon the completion of the duties assigned them Colonel Abbot, Major Mackenzie, and Captain Ruffner will return to their proper stations.

Such journeys as may be required to properly carry out the duties assigned the Board are necessary for the public service.

* * * * * * *

By command of Brigadier-General Duane.

JOHN M. WILSON,
Lieut. Col. of Engineers,
Colonel, U. S. A.

The Board met, in obedience to a notification of the president, at 11 a. m., presen all the members: Col. H. L. Abbot, Corps of Engineers; Maj Alex. Mckenzie, Cor of Engineers; Maj. A. M. Miller, Corps of Engineers; Capt. E. H. Ruffner, Corps Engineers.

The president submitted the letter of instructions to the Board by the Chief of E gineers, dated December 16, 1886, appended, marked A.

The recorder then proceeded to read seriatim the papers accompanying the letter instructions and numbered as therein, and also paper subsequently transmitted to th Board by letter from the Chief of Engineers, dated December 17, 1886.

The Board during the reading of these papers ordered that the following informatio be prepared for its consideration:

(1) Velocity of the current of the Mississippi below the mouth of the Missouri.

(2) The shifting nature of the channel.

(3) Volume and velocity of the Mississippi below the mouth of the Missouri as com pared with same data above it.

(4) Is the channel between the mouth of the Missouri River and the "Eads Bridge stable in position, and if so, between what points?

The Board then directed that letters be sent to parties interested in appearing befor the Board, and that public notice be sent to the newspapers that a public session o the Board be held on the 29th December, at 10 a. m.

The Board then, at 1.30 p. m., took a recess till 2.30 p. m.

2.30 p. m.—Board met pursuant to adjournment. Present, all the members. Th recorder reported that observations of the Mississippi River Commission in 1881 a Saint Louis showed the following velocities and gauge readings.

Date.	Gauge.	Velocity (feet per second).	Discharge (cubic feet per second).	Sediment (parts in 100,000).
1881.				
February 1	22.68	2.45	49,125	[illegible]
March 22	36.21	6.65	370,131	....
April 27	46.33	6.78	711,098	[illegible]
August 19	24.88	2.97	102,651	[illegible]
November 4	39.90	7.62	552,834	....
July 2	39.41	5.62	385,709	[illegible]

These data give extremes of velocity, gauge, and amount of sediment during th period of observation.

The same authority gives for the similar data at Grafton, Ill., below the Illinoi River and above the Missouri River:

Date.	Gauge.	Velocity (feet per second).	Discharge (cubic feet per second).	Sediment (parts in 100,000).
1881.				
January 17	13.89	1.83	27,047	....
February 28	18.61	2.38	96,917	41
February 12	21.33	3.23	141,612	....
February 21	24.07	3.36	173,147	[illegible]
April 12	29.48	4.38	288,156	[illegible]
April 25	32.17	4.59	310,309	22
April 27	33.19	4.58	337,487	15
May 20	28.88	4.12	250,548	....

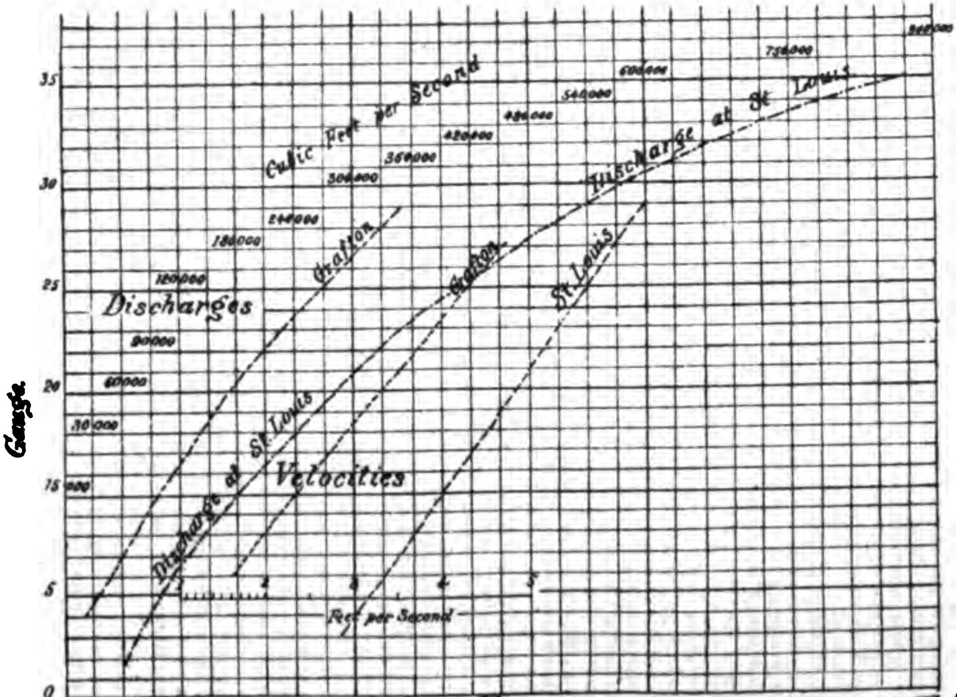
The surveys of the Mississippi River Commission have been platted so as to show discharge, velocities, and gauge-readings at Saint Louis and at Grafton, and a tracing is attached hereto, marked B.

The Board then proceeded to examine the maps of the surveys of the river between Grafton and Saint Louis, executed between 1872 and 1879, and particularly as to the question of the stability of the channel below the Missouri during that time. At 5 p. m. the Board adjourned until 9 a. m., December 29.

WEDNESDAY, *December* 29—9 a. m.

Board met pursuant to adjournment; present all the members.

The president submitted a letter from Hon. D. B. Henderson, forwarding three petitions relating to the proposed low bridge, referred by the Chief of Engineers to the Board by indorsement, dated December 27. The petitions were duly read.



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E.H. Ruffner Enclosure "B"
Capt of Engineers.

At 10.15 a. m. a public session of the Board was opened, as provided for in the session of the 28th.

The president explained the object of the meeting, inviting full systematic details on all points both verbal and written. The supporters of the low bridge were invited first to address the Board. The mayor of the city of Saint Louis, Mr. Francis, extended all facilities and courtesies of the municipal government to the Board in their investigation. Mr. Francis then, as an advocate for the low bridge, further addressed the Board, asking that the opponents of the low bridge be invited to present their side first. Mr. Clark, on the part of the low bridge, stated that the general location of the bridge would be somewhere between North Market street and the reservoir, a distance of about 1½ miles, or 2 miles.

Mr. Francis explained the character of the organization and aims of the merchants' exchange of the city, and of the transportation committee of that exchange. The general plan and character of the bridge proposed was then explained also, and the origin of the bridge bills now before the Board for consideration. Mr. Francis gave financial and commercial reasons for building the bridge and a general location for the bridge between the Chain of Rocks and the Eads' Bridge. Disclaimed any intention of injuring the navigation interest. A bridge is necessary and demanded by all interests, but it is expressly stated that the question of a high and low bridge has not yet been decided upon. Commercial reasons for the bridge are elaborately stated. If the general interests of the city demand a bridge, at the expense of one or more interests, then it is best that those interests should suffer for the interests of others. Reasons why a low bridge might be built are given, and the lumber interests in particular are touched upon, and how they might be benefited or protected.

The president explained reasons for complete investigation and without delay.

Mr. Chapman, on the part of the opposition, suggested that the discussion be limited to the questions of the location of the proposed bridge, and whether it should be a high or low bridge, and gave reasons therefor.

Mr. Francis gave reasons why an exact location of the bridge should not as yet be given further than the general location already given. The question of the high and low bridge should be left to the option of the company, subject to the terms of the bill, and to the War Department.

The president explained that a vital point was the question of the low bridge or high bridge.

Mr. Chapman stated that if the bridge company would confine their demands to a high bridge opposition would cease.

Mr. Francis repeated that the question should be left open, especially since a low bridge has recently been authorized at Alton, Ill. The option of a high or low bridge should be left to the company, and especially since the speaker thought that a low bridge at Saint Louis would not be more an obstruction than a low bridge at Alton.

Mr. Chapman, Mr. Francis, and others entered into a general discussion, during which Mr. Francis stated that no exact estimates for a bridge, either high or low, are the property as yet of the bridge company. Mr. Chapman, on the part of the opposition, opened for that side. He states that the promoters of the bridge propose the bridge for future disposal to railroads, and that in the future such bridge will probably be operated by the railroads, while navigation interests will constantly suffer from it. A low bridge will be an obstruction of great and serious importance—at times actually impassible. Conditions are entirely different here from those above. The Missouri River alters the conditions entirely. The speaker operates many tow-boats with rafts, and he notes and explains the great difficulties in passing a low bridge at Saint Louis, and especially calls attention to the vast drift coming from the Missouri, and the damage possibly done therefrom. Calls attention to the fact that the assertion that a low bridge is either cheaper *ab initio* or in operating has not been substantiated and cannot be proved. Delays to trains from the opening the draws when needed alone will make a low bridge more expensive than a high bridge. The lumber interests of the city, involving 300,000,000 feet, board measure, annually, and 5,900 men, will suffer immensely and could not move if they wished to do so; and a move would be extremely expensive at the best—expense that should not be forced upon one interest by a low bridge. Yet at high water tow-boat with raft could not dare to go through a draw bridge, especially with drift in the river; hence a low bridge would be a direct and tremendous tax upon the lumber interests, which would not oppose a high bridge.

Mr. Francis rose and disclaimed on the part of the promoters of the bridge any personal or private gain from the scheme. While personally in favor of a high bridge, is in favor of retaining the option of making either a high or a low bridge. Gave an account and description of the proposed trustees and incorporators of the bridge.

Mr. Huse arose. He states that he is not necessarily opposed to a bridge; that while a bridge is of course an obstruction, he yet recognizes that a bridge must be the least possible in the nature of an obstruction. Calls attention to the severe velocity in the river below the Missouri, and thinks it twice as great as above there. Shifting channel, sediment, all very difficult, and different from that above the Missouri. Is engaged in ice business on the Illinois and elsewhere.

Mr. Stout calls attention to the character of the river, severe velocity, same features below the Missouri down as far as Memphis; quoted expressions of objections of many bodies to a low bridge; files written papers marked C.

Mr. Clark stated that at extreme high water few boats are running on the river, that drift does not run as much as it used to, and that the current on the Upper Mississippi is perhaps 1 mile an hour less than on the river below the Missouri. Rafts are always broken to go through the draw-bridges on the upper river, and can do so here. The additional current is really the only question involved; the shifting channel can be controlled and kept in one direction, and has been retained near and above the city. Near the water works the channel can be held, and the current is not very great. Commerce is not seriously interfered with by the upper river draw-bridges. The Eads Bridge is the virtual head of navigation, not the Missouri River.

Mr. Stout stated that the passenger boats went up and down 1,700 times last year, that rafts are easily handled at high water, and raftsmen prefer handling their rafts at that time.

Mr. Rainwater stated that a question of expense is the true question of high or low bridge, and that this will be governed by the money available and the cost of operation; therefore the company must have the option of selection, and are not willing to be confined to a high bridge; yet they will build a high bridge if that should be most economical. These plans and estimates will not, nor can they, be made until the passage of a bill authorizing a bridge. Thinks the provisions of the bill are ample to protect the interests of the public; that the promoters of the bridge represent the true interests of the city.

The president then read the order constituting the Board and the letter of instructions to the Board.

Mr. Rainwater wanted the Board to visit the locality and inspect the shores.

Mr. Francis again brought up the commercial questions, and called attention to many topographical features. The Mill Creek Valley is full of railroads, and there is scarcely room for more; north and west are the parks; to the north alone can new roads come in, and a low grade then on both sides of the river is especially a question of importance. But the new location must, of course, have a free connection with the Mill Creek Valley. The only possible way to do this is to go down the levee, and at a low grade, near the river. All of these are reasons for a low bridge, and not a high bridge. Down Commercial alley, and down Second street, and down Main is another possible route to a low bridge from Mill Creek Valley.

A general discussion arose between several gentlemen as to items of commercial importance, involved in the question of a high or low bridge, and of the amount of interest involved.

The Board decided not to visit the localities referred to, as sufficient exact information as to locality and grade had not been furnished.

At 1.15 p. m. the Board adjourned till 2.30 p. m.

2.30 *p. m.*—The Board met, pursuant to adjournment; present, all the members. Further expression of opinion was invited. Mr. Chapman asked an expression of opinion of Captain Ward, an experienced navigator, as to the current and drift of the river below and above the Missouri. Captain Ward states that the current below the Missouri River was greater than above the Missouri, and that much more drift is found below than above; that it is easier to run a draw-bridge on the Upper Mississippi than at St. Louis, or below the mouth of the Missouri; both on account of the current and drift. Thinks the channel would change very much; doubts if it could be held in one place. Channel changes were below the city limits.

Captain Leyhe, of the steamer *Spread Eagle*, between Saint Louis and Alton, running daily up and down—*i. e.*, would have to pass such bridge sixteen times a week—says current below Missouri would run as high as 7 miles an hour when the gauge reads 25 feet and rising; a draw-bridge could not be run at all sometimes; drift and storms would make it very dangerous.

Drift sometimes runs so heavy in spring that boat could hardly make a landing. Above the Missouri there is no drift, and there is less current than below; no difference as to wind; and there is more shfiting of channel below than above and more cross-currents. The *Eagle* made 560 trips in 1886, and carried some 45,000 passengers. The company own four boats, three of them tow-boats. Channel is exceedingly shifting below mouth of Missouri, and in fact he is asked by the Saint Louis and Saint Paul Packet Company pilots at Alton where the channel is, as it sometimes changes during the week. This stretch is run by day at low stages when they can do so. Two-boats double trip it sometimes up to the mouth of the Missouri. The *D. A. Lyle* has carried four barges up-stream, two on each side, total width 185 feet; barges carry 39,000 railroad ties, about 3,000 tons. He has run the Louisiana bridge with that tow; has come down the river with the *Lyle* and four empty barges, hitched two on each side of the boat, and to pass the bridge at Louisiana turned around and backed through. The drift-wood has not changed materially in the eight years past. During the year probably there would be two periods of about three weeks each when the amount of

drift would be enough to seriously interfere with the passage of a draw-bridge. The drift generally follows the channel. Would rather, three to one, take the *Lyle* through the "Eads" Saint Louis Bridge down-stream with a tow than the Louisiana Bridge, 200 feet draw.

Captain Kirns, a pilot since 1862 on the Upper Mississippi, but not constantly since the last eight years: Below the Missouri River a draw-bridge would be much more dangerous than a similar bridge above that mouth, he thinks. Gave reasons for thinking Bissel's Point a bad place for a bridge. All the draw-bridges on the upper river are great obstructions, each one necessitating a double trip, or split of the raft, entailing a delay of two, three, or more hours at each. Below the Missouri there is no place to land a tow at high-water and effect this change, the banks being under water. A draw-bridge at the upper part of the city of Saint Louis would be hardly passable; and when drift comes and catches a boat backing to flank in, it would be apt to disable the boat entirely. The largest tow carried by any of his boats was about 2,700,-000 feet, board measure, or 700 feet long and 235 wide in all, including the boat; 14 strings. He can not handle that much now below the Missouri at high water, but takes one-half at a time, and in low water more, say 8, 9, or 10 strings, below Alton Slough. Once the stage of water was so high that he could not bring his tow below Alton at all, on account of the drift, but generally he is able to bring a part down. Rafting begins about the middle of April, then about two to three months of high water.

During the course of years, say fifteen years to twenty years, the rafting time from Lake Pekin to Saint Louis has not materially changed, because rafters are more apt to run by night now than formerly between the bridges. Has paid as high as $2,400 damages caused at bridges through accidents; once as high as $3,000. Direct collision with a bridge has caused him $1,700 or $1,800 at Quincy, Had two accidents on one trip. Never had a year go by when he did not lose more or less by the bridges, probably has averaged somewhere between $800 to $1,000 a year. If all bridges on the Upper Mississippi were high bridges, with 300-foot spans, there would probably be no loss at all, and he would save four to five days on each trip. The present condition of affairs causes constant loss of time at each bridge, and when the wind blows sometimes they are obliged to lay up entirely above a bridge. In 1886 he brought twenty-three rafts to Saint Louis, of which five or six came through without being divided up in passing the bridges.

Captain Hill, of the Eagle Packet Company, thinks the proposed bridge would be a serious objection, but that a high bridge would not be objectionable if 500-foot span, and 50 to 60 feet above high water. Gave same reasons as others, and in particular that when the wind is high the passage of a draw would be hazardous. When wind is high the boat must wait above the bridge. Drift is dangerous, and would be always troublesome at high water. Gives reasons for thinking that a draw-bridge at Alton would be much easier to run than one at Saint Louis, the conditions being entirely different at the two places.

Captain Dodd, a pilot on the river for about twenty-eight years, working every season, thinks there is not much to add to what has been said, but that, in his opinion, a low bridge would be detrimental. With a tow coming from Alton it would be dangerous to pass the bridge at any time, and with drift it might be fatal. A bridge where proposed would be a direct expense to the lumber yards below it, and sometimes rafts themselves could not be landed at all. Average time running a raft from Reed's Landing to Saint Louis is about ten days; quickest eight days, in June; sometimes as much as fifteen days in low water. From two and one-half to three days lost on each trip by delays at the bridges, and he has been known to lay more than two days at one bridge waiting for the wind to go down. If bridges were all high much time would be saved. Below Missouri conditions are different; very bad to land if necessity arose.

His boat, the *Charlotte Boeckeler*, has not more than a half a dozen equals in power in the ninety-five or a hundred raft-boats on the river. Perhaps twenty raft-boats reach Saint Louis. Changes in the channel below the mouth of the Missouri are frequent and excessive after every rise; would be difficult to keep the channel through the draw at all times. Has run rafts 280 feet wide; one-half would be 140 feet. Had one break-up on the Rock Island Bridge and lost about $1,500; another this fall at the Keokuk Bridge, about $600. Ran fourteen trips this year. Has accidents from other causes besides bridges, but thinks that losses from bridges are greater in the average than from other causes; possibly $600 a year would cover all losses, of which $450 due to bridges—light estimate, perhaps. Channel below the Chain of Rocks generally reasonably stable, though sometimes varied; at the Chain of Rocks it constantly varies.

No two years does the channel run exactly the same place; below the water-works somewhat more stable. June best month for business; May, June, and July best three months. Drift even this year when there was no high water. Have had difficulty in landing on account of drift; in fact, have been obliged to get another boat to help land a tow.

About three years out of five the channel will be near the Missouri shore below the

Chain of Rocks. The most changeable place is abreast of the Chain of Rocks, and below, varying in every position.

At 5.40 p. m. the Board adjourned until 10 a. m. to-morrow, December 30.

December 30, 10 *a. m.*—The Board met pursuant to adjournment; present, all the members. Proceedings were read and approved, and at 10.30 a. m. public session was opened. Col. Henry Flad, who had been specially invited by the Board to give his opinion as to the relative cost of high and low bridges, said:

At the water tower and at the engine house rock was reached at 80 feet below directrix. All the piers would be 100 feet or more below directrix; east abutment need not go to the rock, but the piers must go to the rock in all cases, wash being excessive. Long spans at deep rock foundations are cheaper than short spans; cheap iron has made long spans advisable. Not less than 80 feet foundation to bed-rock can be hoped for. Difference in cost between high and low bridge depending on difference of masonry, difference of grade, and difference of spans. Cost of approaches would be perhaps $100,000 more on west side for a high bridge; dike on the east and abutment the same for both bridges, on east side high bridge perhaps $100,000 more. Draw pier would be very expensive.

High bridge would perhaps cost 10 per cent. more than a low bridge, using same piers and spans; 500 feet spans, also one with two 750 feet arches—very approximate estimate.

"Upon the whole, I am decidedly of the opinion that the high bridge is much more desirable on every account." Operating expenses of a draw would be a serious loss to a bridge, much more than to operate an ascending grade on a high cantilever bridge. On a double-track high bridge, three spans of 500 feet each, an estimate of $1,208,000 was made by an engineer of high standing—name reserved. Colonel Flad's own estimates were, for the low bridge, $1,800,000, and for a high bridge, $2,000,000—truss bridges. One estimate was for two spans, each 762 feet spans, say, $2,200,000, in lump sum. Iron and everything else estimated with high figures. Engineers vary in opinion, some thinking that there would be little difference in cost between high and low bridge, and others think as much as 20 per cent. difference might exist. Colonel Flad's plans propose a bridge where the lower chord gives the entire width between the piers as free-way, and thus much better for navigation than the Eads bridge.

The processes of sinking the foundations are much improved of late years, and piers can be much more cheaply built now than heretofore. Land damages will not be great for either side of the river, and on the east side can not be different for a high bridge or a low bridge. On the Saint Louis side probably $20,000 will cover the difference. There will be no practical difference between connecting a high bridge or a low bridge with the Mill Creek Valley. Additional railway of perhaps 1,000 feet more will be needed for a high bridge; not more. A high bridge would easily reach the Wabash tracks. Colonel Flad was thus far questioned by the Board; after this, questions were asked by others.

Difference between high and low bridge is to be 40 feet. Low bridge to be 10 feet and high bridge 50 feet above directrix. Approaches to be 1 to 100, or 52.8 feet per mile. The banks are low on both sides of the river where the proposed bridge is to be. A change in the grade of the approaches to that necessary for the high bridge would entail absolutely no increase in cost, as trains do not average anywhere near the maximum load on the engine. All trains coming into East Saint Louis are on roads that rarely have less than 1 to 100 of grade. There will be no increase to these expenses if the new bridge be high.

The new bridge approximately located a short distance below the water works, and he thought this a good location, though he knew that no exact location had been made by the company.

Leaving that bridge, whether a low bridge or a high bridge, a track back to the Wabash track is necessary under all circumstances, and the only difference in cost and operation will be that necessary to secure an addition of perhaps 500 feet of land; land that will not cost much. An extended questioning was then made to cover the points for which Colonel Flad had given his opinions, which he explained in detail, in substantially unchanged position. An essential feature of all the plans of Colonel Flad was that on the east side a dike should extend to the east abutment, leaving a clear water-way of 1,500 feet, the same as at the Eads Bridge, this dike to be high-water line and the trestles of the bridge approach on top of this dike.

At this point Mr. Rainwater submitted an estimate of Mr. Corthell that a low bridge would cost $1,500,000, and that a high bridge would cost 50 per cent. more, besides cost of approaches and land. To this Colonel Flad stated that he had a letter from Mr. Corthell stating that he had never made an estimate of a high bridge.

Mr. Francis then made remarks to the Board, explaining section 12 of the proposed bridge law.

Mr. Nicholson stated that commerce demands a bridge, and a low bridge would be just and necessary, even if river or other interests suffer.

Mr. John N. Booth explained the necessity for a bridge, and that a low bridge would be necessary if money for a high bridge could not be got.

Mr. John T. Davis said a new bridge was necessary, and that must be the cheapest possible bridge.

Mr. John R. Holmes agreed with remarks of the preceding speakers; thinks a low bridge will not be an obstruction to navigation, both from his observation and from conversation with river men; gave his reasons for supporting a low bridge.

Ex-Governor E. O. Stanard, as a business man and not as an incorporator of the bridge, gave expression to the views of the business men of the city. He avowed his opinion that the river interests of the country would not suffer at his hands or from the incorporators of the bridge. He gave financial and commercial reasons for the construction of a new bridge at Saint Louis as a necessity for the business of the community. While he recognized that river interests naturally oppose all bridges, and that such feeling is natural and right, yet he knew most positively that forty-nine out of fifty men in the city of Saint Louis are in favor of a low bridge rather than no bridge, and that if a high bridge will cost too much and a low bridge can be built so that charges over it can be so low as to permit a reasonable competition with the Eads Bridge, then the low bridge should be built.

The gentleman then gave his reasons, as a business man, not as an engineer, why he thought low bridge at Saint Louis should not cost more here than on the upper river; that business and railroad men on that river always selected low bridges because they were most economical and advantageous. He proceeded to explain the character of the incorporators of the bridge, and that their high standing is guarantee enough that the question of high and low bridge can be best left to them; who can choose from the various plans and estimates submitted to them the plan that will seem most advantageous to their means and aims. Gave his reasons for believing that the incorporators would do all that men could do consistent with the welfare of the community.

Mr. Haarstick stated that parties are not opposed to the building of a high bridge; that he, as a director of the Merchants' Exchange, and as a supporter of the proposed plan, and having voted for everything, is yet himself opposed to that feature of the bill allowing an option for the selection of a high or a low bridge. As chairman of the committee of the same exchange on the improvement of the Mississippi, he then read resolutions of that committee, and submitted them to the Board (appended marked D); gave reasons of the committee for taking this action. He then emphasized the expression of opinion that all were in favor of a bridge; but that there is a decided difference of opinion in the exchange as to the desirability of a low bridge; and that many prefer a high bridge. Explained relation of this committee to the board of directors, which board itself voted down the resolutions themselves. The resolutions show the opinion of a minority of the exchange. Mr. Haarstick represents the barge-line business on the lower river, and therefore is opposed to the introduction of additional obstructions to the river, in the shape of low bridges. They fear that a low bridge at Saint Louis will be a bad precedent in the future for localities on the lower river. Described the decline in the river traffic at Saint Louis, and assigned the cause in large measure to the bridges on these rivers.

While the action of the Saint Louis Merchants' Exchange in asking the General Government for money to improve the rivers has been a part of their past history, this is not consistent with their action in furthering the project of introducing a great obstacle in the shape of a low bridge. The difference between high and low bridge, whatever this might be, should be met from a policy of true consideration for the general welfare; and that this difference of cost alone should not prevent the building of the high bridge. Commerce on the river below Saint Louis will probably increase with the next five years. A high bridge should be one built with a straight chord, 50 feet above high water. The Eads bridge he does not consider a high bridge; it is unsafe, and the large boats of their line are not sent above the bridge because it is dangerous. To go through a 200-foot draw he would be obliged to break his tow, but the Eads Bridge itself is so dangerous that they would not undertake to go through it.

Captain Scudder of the Anchor Line packet running below Saint Louis, said: The Eads Bridge is a total obstruction to his boats, and no one of their boats ever go through the Eads Bridge. He thinks no bridge should ever be built without a draw on one side. Disasters at bridges raise the rates of insurance, making an aggregate steady charge against boats. Has had no practical experience with draw-bridges himself.

Mr. S. W. Cobb submitted an extract from a letter written by Mr. E. L. Corthell, giving an estimate of the cost of a proposed low bridge, marked (E).

Mr. Simmons thinks that the most pressing need that Saint Louis has is a bridge with reasonable tolls, both on account of rates and time. Explains methods of railroad rates, and how they are used against Saint Louis; gives details and examples of his business. Business demands a bridge as near a free bridge as is possible.

Mr. Chapman argues and comments on the remarks already made, refers to the arguments of all natures, and desires to return and confine the discussion and investigation to the true question of high bridge and low bridge. Made an argument in favor of a high bridge.

Mr. Cummings, a member of the city council, states that the council had passed a

resolution asking Congress to add into the proposed bridge a rate of toll to be charged on the new bridge; states that the bill should be specific on that point. Is satisfied that a low bridge, particularly where proposed, would be a very great obstruction, and in especial would be destructive to the lumber interests. A high bridge is especially desirable.

Mr. Huse, of Huse, Loomis & Co., is a large shipper, from 2,000 to 3,000 cars a year, and therefore can speak from experience as to railroads, yet is positive that a high bridge is infinitely preferable to a low bridge. Was a tow-boat pilot and captain in former years, and can speak from experience as to the dangers of navigation, particularly as to draw-bridges. Explains the details of such, and described a collision of one of his boats with the Hannibal Bridge when going up-stream with empty tow, involving a total loss of boat and tow, thirteen lives, and a span of the bridge. Described difference between rivers of the West; explained methods of towing on the Illinois; also described his boats and barges, difficulties of coming through the Eads Bridge; thinks a low bridge below the Missouri would be a fatal blow to the commerce coming down the river, and that most of that commerce coming in the shape of tow-boats, rafts, and barges, would suffer especially.

The shifting channel alone would be an insuperable objection below the Missouri; describes how the channel shifts even directly in front of the city. No draw-span can be located, there being no straight shore. Thinks the whole question altogether too small on the part of the bridge men to propose to put in a low bridge when, for a small additional cost, a high bridge can be put up. Explains all the difficulties of wind, current, drift, and eddies in the navigation through the draw-bridge, and the risks to life and property always run by tow-boats at the bridges. For these considerations of life and property an additional cost should be put into the bridge and make it safe for the river interest. His large experience in both river and railroad extended over a period of many years. A low bridge here would practically ruin the river business and probably run all tow-boats out of the river. Trouble of managing tows due to load. Add expenses of each trip, double tripping, two days' time. At times his boats have taken up-stream fifteen barges at once.

Mr. F. L. Johnston, secretary St. Louis and St. Paul Packet Company: We pass through all the bridges up as far as Saint Paul. At every one of the bridges on the upper river excepting five we have lost one or more or damaged one or more boats or barges. Accidents of every possible kind have happened, and we have tried every possible way of avoiding these accidents. For packets without barges, the safest way to come down, head on with good steerage way. I think it would be doubly dangerous to run a draw of 200 feet below the Missouri than above.

Mr. Schulenberg, of the lumber firm of Schulenberg & Baeckeler, is in favor of building a low bridge on account of the difference of expense of building and operating a low bridge, the length of the approaches, and the difference of level. Would rather have the bridge below his landing than above.

Mr. Francis explained as to railroads to come into the city.

Mr. W. H. Jones, interested in railroads coming into the city, thinks that low grades are essential to the operation of railroad. Is interested as to location of the bridge, questions the accuracy of many statements as to the injury to be done with the lumber interests, but submits no facts.

Mr. Charles W. Beers, secretary of the Schulenberg Company, explains that the company as a whole has fought the bridge as a low bridge, and that Mr. Schulenberg has given his testimony on his own responsibility.

Mr. Francis, on the part of the bridge, disclaims any intention of injuring the lumber, ice, and river interests of the city.

Capt. W. R. Slocum has been a pilot on the river for eighteen years, rafting lumber and logs, landing at Saint Louis about once a week, bringing them from Alton Slough. Brail of logs explained in construction, and what damage could be done by striking a pier.

The public meeting then closed at 2 p. m.

Recorder submitted statement of cars crossing Illinois and Saint Louis bridge during 1885 and 1886; appended, marked F.

The Board then, until 6 p. m., was occupied in discussion and preparation of its report; and at 6 p. m. adjourned until 9 a. m. to-morrow, December 31, 1886.

December 31, 1886, 9 *a. m.*—The Board met pursuant to adjournment, and continued in session until 6 p. m., engaging in completing record and preparing report. Recorder submitted statement of the Saint Louis Bridge and Tunnel Company, showing traffic across the "Eads bridge" in 1885 and 1886; appended, marked "G."

At 6 p. m. Board adjourned *sine die*.

E. H. RUFFNER,
Captain of Engineers.
HENRY L. ABBOT,
Colonel of Engineers,
Bvt. Brig. Gen., U. S. A.,
President of Board.

A.

LETTER OF INSTRUCTIONS TO BOARD OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 16, 1886.

SIR: The inclosed communication to the Secretary of War from the Hon. S. J. R. McMillan, chairman Committee on Commerce of the Senate of the United States, and accompanying papers, in relation to low bridge at Saint Louis, are transmitted for the information of the Board of Engineers, constituted by paragraph 2, Special Orders No. 195, Headquarters Corps of Engineers, dated December 16, 1886, of which you are the presiding officer.

The importance of the subject and the great interest manifested by commercial and other bodies in regard to it, renders it necessary that the Board give the matter thorough investigation and consideration, and submit a full and exhaustive report, accompanied by such evidence as may be deemed advisable, tending to fortify and elucidate the opinions it may be called upon to submit.

The Board is authorized to hold open sessions, if desired, and to call upon the officers of the Corps of Engineers stationed in Saint Louis for such aid and information as they may be able to afford.

The expenses of the Board will be defrayed by Maj. A. M. Miller, Corps of Engineers, from the appropriation for improving the Mississippi River from the mouth of the Illinois to the mouth of the Ohio River.

By command of Brigadier-General Duane.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Colonel of Engineers,
Brt. Maj. Gen., U. S. A.

Col. HENRY L. ABBOT,
Corps of Engineers.

C.

PAPERS PRESENTED BY MR. STOUT IN OPPOSITION TO A LOW BRIDGE.

1.—*Letter of Mr. D. A. McDonald.*

MCDONALD BROS., LUMBER AND TOW BOATS,
La Crosse, Wis.

MY DEAR JUDGE: I see that you take a very lively interest in the legitimate improvements of the Mississippi River, and that you are very active in your opposition to the construction of a low bridge at Saint Louis. I may be too late in dropping you this letter.

You are aware that for a great many years I was actively engaged in navigating the river to Saint Louis, and consequently have a knowledge of the character of the river and its banks and islands. The shores and islands are of recent alluvial deposit, and the ever-shifting sands of the river are not much more fickle than are its uncertain banks and islands. Our pilots, who are constantly running from here to Saint Louis, dare not go below the mouth of the Missouri in low water until they have learned from some one who has just been over that part of the river what changes had taken place since their last trip, or else engage the services of a pilot who has just been over that part of the river.

It might stagger the member of Congress from Saint Louis to know that the mouth of the Missouri River has moved at least 4 miles down-stream in the last dozen years; that it is not a great many years since an Illinois farm occupied the place of the present mouth; that Wilson's Island, on which there was a farm, peach orchard, etc., less than ten years ago, is now in the Gulf of Mexico. (This island was about 11 miles above the present bridge.) For a short distance in front of Saint Louis, but below the proposed site for new bridge, the river has been narrowed to about 1,600 feet by extending a dam from the head of Bloody Island to the Illinois shore, and the river thus walled in between the natural rocks on the Saint Louis shore and the artificial embankment of rocks on Bloody Island has a channel swift, deep, and regular. But as soon as it is released from this bondage and permitted to resume its natural width it immediately resumes its former vagaries, as the immense sums expended in the immediate vicinity of Saint Louis attest. Please pardon me for suggesting that when the privilege is granted to place a bridge across the Mississippi River that no mere

matter of cost should determine the kind of bridge which should be permitted; that the greatest security to life and property should be the prime and only consideration.

Now, for the reasons already set forth, the channel in that part of the river can not be maintained at any given point, but must be permitted to go as it pleases to any opening in the bridge.

Therefore, in the interest of navigation and to secure the safety of life and property, every span in the proposed bridge should be a draw-span of not less than 300 feet, or a high bridge should be insisted upon.

Yours, very truly,

D. A. McDONALD.

Hon. W. T. PRICE,
Washington, D. C.

Affidavits showing shifting channel.—William Kelly, pilot 20 years; M. L. Kelly, pilot 18 years; M. B. Chapman, pilot 20 years; J. M. Gilhorn, pilot 28 years; Henry Legbe, master and pilot 20 years; W. C. Ball, master and pilot 30 years; George G. Keith, master and pilot 30 years; A. Lemont, master and pilot 27 years; E. R. Powell, master 25 years; W. R. Slocumb, master and pilot 20 years; J. W. Little, pilot 36 years; Samuel C. Gulich, pilot 36 years; Henry Doft, pilot 23 years; Henry H. Hicks, master and pilot 28 years; George W. Allen, master and pilot 25 years; Ezra J Chacey, master and pilot 16 years; Robert Dodds, master and pilot 17 years; Jos. La Barge, pilot.

RESOLUTION PASSED BY NATIONAL BOARD OF STEAM NAVIGATION.

Resolved, That in the opinion of the National Board of Steam Navigation there will be a serious detriment to the free and safe navigation of the Mississippi River to have a bridge or bridges with a draw, or of a less elevation than 50 feet above high-water mark or with narrower spans than those of the Saint Louis Bridge, known as the Eads bridge, at any point within 20 miles of the city of Saint Louis, Mo.

The Board also recommends a rigid adherence to the provisions of the law relating to the Ohio River, with the application of said law to other navigable rivers.

RESOLUTIONS PASSED BY THE LOUISVILLE CHAMBER OF COMMERCE.

Whereas a bill is before Congress, known as House bill 8745, for the construction of a low railway bridge across the Mississippi River at or near Saint Louis; and

Whereas a bridge constructed in accordance with the provisions of said bill will be a serious obstruction to navigation and injurious to the trade and commerce of said river: Therefore,

Resolved, That we earnestly protest against the erection of any bridge over the Mississippi River south of the mouth of the Missouri River with a less channel height or width than the channel spans of the present bridge at Saint Louis; and further

Resolved, That a copy of these proceedings be furnished to our Senators and Representatives in Congress, with the request that they most earnestly oppose the passage of the bill, or any other bill inconsistent with the above resolutions.

RESOLUTIONS PASSED BY PITTSBURGH CHAMBER OF COMMERCE.

CHAMBER OF COMMERCE OF PITTSBURGH,
Pittsburgh, Pa., June 15, 1886.

DEAR SIR: At the meeting of the chamber held yesterday, 14th instant, the paper following was unanimously adopted:

"Whereas a bill is now before Congress known as House bill 8745, for the construction of a low railway bridge across the Mississippi River at or near Saint Louis; and

"Whereas a bridge constructed in accordance with the provisions of said bill will be a serious obstruction and injurious to the trade and commerce of said river: Therefore,

"*Resolved,* That we earnestly protest against the erection of any bridge on the Mississippi south of the mouth of the Missouri River with a less channel height or width than the channel span of the present bridge at Saint Louis."

It was also

Resolved, That a copy of these proceedings be furnished our Senators and Representatives in Congress, with the request that they most earnestly oppose the passage of bill, or any other bill inconsistent with above resolution.

We mail to-day to our Senators and Representatives in accordance to resolution.

In some haste, respectfully, yours,

G. FOLLANSBEE,
Superintendent.

J. H. STOUT, Esq.,
Biggs House, Washington, D. C.

COMMUNICATION OF MR. WILLIAM L. HUSE, PRESIDENT HUSE & LOOMIS ICE AND TRANSPORTATION COMPANY, TO THE EDITOR OF THE GLOBE-DEMOCRAT.

SAINT LOUIS, *May* 15, 1886.

DEAR SIR: Will you allow me to give to the public, through the columns of your paper, a few of the reasons why I have so strenuously opposed the movement to obtain a charter for a low bridge below the mouth of the Missouri, and to beg your readers to carefully consider them with me, and then decide if there may not be another side to this low-bridge question.

We, who have opposed this move from its first inception, have done so because our material interests were seriously involved, but we are for the moment on the unpopular side. Why are we called obstructionists? Have we not repeatedly said that we were not opposed to a properly constructed high bridge, that will conserve both the river and railroad interests without delay or danger to either? From experience we are firmly convinced that a low bridge, with narrow draw, is extremely dangerous to all life and property passing through down-stream, more especially to tow and raft boats. With a narrow draw, or opening of only 200 feet (as proposed in this bridge), an ordinary tow will only have 30 or 40 feet of space on either side. It is asking more than human skill to require any pilot to run a tow through that narrow space safely with any wind or the least variation of current. Even in the calmest weather it would be very unsafe, and if they miss the draw-opening certain destruction awaits them by being drawn under the low superstructure, placed but a few feet above the water.

There is no overdrawn estimate of the danger. Our company a few years since had exactly this experience. Our powerful tow-boat, the Dictator, was drawn under the Hannibal bridge, capsized, and sunk; eleven of her crew were drowned; steam-boat and tow a total loss; one span of the iron bridge carried away, stopping railroad traffic for several weeks.

In the past ten years our company has lost over $40,000 of property and fourteen lives through collisions with railroad bridges; and the indirect money losses by delay at night and in windy weather at these bridges aggregate four times that amount. And yet, we and others, protesting against a low bridge as dangerous to life and property, are called obstructionists. The friends of the low bridge claim that, since there are so many similar ones, this in addition makes but little difference. This is not true, since the conditions are entirely different. The draw-bridges over the Upper Mississippi and Illinois rivers are where the current is only 2 or 3 miles per hour, usually; in extreme cases 4 miles. Below the junction of the Missouri the current often runs from 6 to 7 miles per hour; in extreme high high water 8 miles. No tow or raft steamer can pass the upper river bridges safely with more than they can back up against the current; hence they might pass the upper bridges safely in the slack current and be destroyed under this proposed bridge, being unable to hold their tow in the swifter current.

President Cobb said, in a late article, that the Eads bridge had proven quite as dangerous as draw-bridges. I wish to ask him, would not the danger to life and property be increased twenty-fold if the 525-foot space between the piers were reduced to a 200-foot opening, with a death-trap in the shape of a low superstructure placed a few feet above the water? Many erroneous statements have been made, one of which I wish to correct. It is claimed that 90 per cent. of the volume of river business is below the city. Is this true? There are over 1,500,000 tons of lumber, stone, and ice brought to this city annually from the north by river, not mentioning all other articles. Does any sane man think there is ten times that tonnage leaving this city for the south by river?

Is the so-called "Merchants' Exchange bridge bill" sailing under false colors? If I understand the matter correctly, the Merchants' Exchange has not a dollar's interest in this bridge. Is it not a private bill of a few individuals, members of the Exchange? And when the charter is obtained, will it not be transferable to any railroad company?

They have asked for a charter to build either a high or a low bridge. If a high bridge is intended, why the menace of a low one? Are life and property to be perpetually endangered to save the small sum of $200,000 on a $2,000,000 bridge? It is an open secret that the best engineering talent in the West has given them careful estimates, placing the cost of a high bridge less than 10 per cent. more than a low bridge.

Are the friends of the low-bridge consistent?

Did not the Merchants' Exchange in 1882 decide against any low bridges below the mouth of the Missouri?

The residents of Saint Louis may as well look squarely in the face the fact that the first low bridge below the mouth of the Missouri will be the beginning of a series of low bridges to cross the river at Carondelet, Chester, Cairo, Belmont, and Memphis, and that the indorsement of this bill by them will forever silence any opposition they

may wish to make to the erection of low bridges below Saint Louis over the Mississippi.

Have they not sent delegations to Washington, asking large appropriations from Congress to improve nature's great highway, the Mississippi River, and to keep it open to the commerce of the country free from obstructions?

And now they are asking the privilege to put in a greater obstruction to navigation than nature has ever made between the Keokuk Rapids and the Gulf of Mexico.

"Consistency, thou art a jewel."

WM. L. HUSE,
President Huse & Loomis Ice and T. Company.

To the Editor of the Globe-Democrat.

D.

RESOLUTIONS PASSED IN MAY, 1886, BY THE MISSISSIPPI RIVER IMPROVEMENT COMMITTEE OF THE MERCHANTS' EXCHANGE OF SAINT LOUIS, MISSOURI.

OFFICE OF SAINT LOUIS AND MISSISSIPPI
VALLEY TRANSPORTATION COMPANY,
Saint Louis, December 30, 1886.

DEAR SIR: In accordance with your request, I beg leave to give you below a copy of the resolution as passed by committee on Mississippi River improvement, of which I am chairman, and the members of which are appointed by the Board of Directors of the Merchants' Exchange of this city.

The committee met in May last, and, after passing the resolutions unanimously (seven members being present and three absent), requested President S. W. Cobb, of the Merchants' Exchange, to telegraph a copy of them to a committee in Washington, D. C., consisting of Governor Stanard, Mayor Francis, and Mr. Rainwater, who were there for the purpose of inducing Congress to pass the merchants' bridge bill, in which the builders should have the option to build a low or high bridge, *after* obtaining the franchise from Congress.

I also give you a copy of a telegram sent the committee in Washington and accompanying our resolutions, which requires no comment from me.

The Mississippi River Improvement committee passed the following:

"Whereas the city of Saint Louis requires another bridge across the Mississippi River, to enable its commerce to prove commensurate with its geographical position, as well as to increase its terminal and switching facilities and become independent by the bridge competition secured to it by the building of the new, and as near a free bridge as can be had, charging only such tolls as will maintain it in good running order and pay a nominal rate of interest on the stock and a low rate of interest on the bonds:

"*Resolved,* That in common with our fellow-citizens we recognize the imperative necessity of another bridge, which we cordially indorse and will earnestly support. Still, we also recognize the value of an improved, unimpeded, and unobstructed river to the seaboard, and believe that the Father of Waters, the freight-rate regulator, should not be lost sight of in the march of improvements, looking to cheaper transportation of the products of the Mississippi Valley; and we hereby oppose the granting of any charter of a low bridge by Congress across the Mississippi River below the mouth of the Missouri, but pledge our hearty support to a high bridge, with a 500-foot span, as least likely to impair said river navigation so essential to the material prosperity of the country.

"HENRY C. HAARSTICK.
"FRANK GAIENNIE.
"M. MCENNIS.
"J. C. EWALD.
"JAMES L. HUSE.
"M. BANHEIMER.

"By request I send this as the sense of the members of the committee present. The Board of Directors has not acted upon it.

"S. W. COBB,
"*President.*"

River committee met to-day, six present. They heartily approve a high bridge, and if you are willing to accept they say all opposition here and in Washington will join in pushing the bill through this Congress. Stout has been requested to confer with

you. The directory has not, and may not, indorse the river committee's report. Being on the ground, you know whether concessions are necessary or not.

S. W. COBB,
President.

I respectfully ask that the above be placed before your Board as evidence against the building of a low bridge below the mouth of the Missouri, together with the remarks I made before you to-day.

Very truly, yours,

HENRY C. HAARSTICK.

Maj. E. H. RUFFNER,
United States Engineers.

E.

EXTRACT FROM LETTER OF MR. E. L. CORTHELL, GIVING ESTIMATE OF LOW BRIDGE.

WASHINGTON, D. C., *May* 29, 1886.

MY DEAR SIR: * * * I am satisfied that a low bridge can be built for $1,500,000. That is, under the circumstances and at the same location a high bridge will cost 50 per cent. more than a low one, saying nothing of the increased cost of land approaches for a high bridge and the great inconvenience of getting upon the ground that is suitable for the yards and tracks.

* * * * * * *

E. L. CORTHELL.

Mr. S. W. COBB,
President Merchants' Exchange, Saint Louis, Mo.

F.

STATEMENT OF TRAFFIC ACROSS THE ILLINOIS AND SAINT LOUIS BRIDGE IN 1885 AND 1886.

SAINT LOUIS BRIDGE COMPANY AND TUNNEL RAILROAD,
GENERAL MANAGER'S OFFICE,
Saint Louis, December 30, 1886.

DEAR SIR: In reply to your favor of this date, I beg to say:

First, as to average number of trains.

A. There are 84 passenger trains crossing daily on schedule time. This is exclusive of special and excursion trains.

B. The number of coaches, including express and baggage cars, hauled during 1885, was 214,828, which gives an average of about 7 cars per passenger train.

C. As to freight, the number of freight cars moved across the bridge during 1885 was as follows:

Loaded cars	186,687
Empty cars	132,217
Total cars	318,904

Averaging about 15 cars per train gives a total of 21,260 per annum, or about an average of 60 trains per day.

D. There is an average of about twenty light engines crossing the bridge daily, which, inasmuch as the bridge and tunnel are operted on the Block system, count as trains, and must be taken into account in enumerating the number of trains.

Second. As to the greatest number of trains crossing the bridge on any day during the present year, I would say that the largest number of freight cars was transferred on the 16th of January, to wit:

Loaded freight cars	1,036
Empty freight cars	476
Total freight cars	1,512

making an average of over one hundred trains.

The largest number of passenger trains in any one day was on the 20th of September when we moved 108 trains, regular and special.

The above figures apply to the traffic of 1885 (except as to the two specific days in 1886).

During the present year and up to the 20th instant, inclusive, we have moved 185,37 loaded and 124,050 empty freight cars, making a total of 309,421, or 9,483 cars less than in 1885. This is accounted for by the nearly total interruption of the bridge traffic lasting six weeks, during the Southwestern strike, and the eleven days in December 1886, not yet reported.

In addition, allow me to say that we will be glad to furnish you any information respecting the traffic, operations, earnings, and expenses of our companies, and that the books and records of this office are open to your inspection for that purpose at any time.

Yours, very truly,

WM. TAUSSIG,
General Manager.

Capt. E. H. RUFFNER,
United States Engineers.

G.

DISCUSSION OF INTERFERENCE IN TRAFFIC, BY MAJOR MILLER.

Traffic over existing bridge.

The railroad traffic over the present, or what is known as the Ead's Bridge, is very large. The number of coaches, that is, passenger cars, baggage, and express cars, which crossed in 1885 was 214,828. The number of passenger trains crossing daily was 84, which gives an average of 7 cars per passenger train.

The number of freight cars moved across in 1885 was:

Loaded cars	186,687
Empty cars	132,217
Total	318,904

This at an average of 15 cars per train gives a total of 21,260 trains per annum, or about 60 trains per day.

The greatest number of freight trains crossing the bridge in any one day in 1886 was 100. The largest number of passenger trains crossing in one day in 1886 was 108, regular and special.

From the 1st of January to the 20th December, 1886, both dates inclusive, there have been 309,421 freight cars, loaded and empty, hauled across the bridge; this is 9,483 cars less than in 1885; but there was a nearly total interruption of bridge traffic for six weeks this year, owing to strikes.

From what is stated above it will be seen that a fair average would be a traffic of 144 trains crossing the bridge per diem.

Probable traffic over the new bridge.—Now it is hardly probable if a new bridge were built at Saint Louis that it would be required to accommodate this amount of traffic; but if it is to be of practical value as a measure of relief to the trade of Saint Louis it should be able at least to divide this business. Let it be supposed that half this number of trains were required to be crossed over this bridge, this would give an average of 72 trains per diem. Now if the bridge were a low bridge, with a draw required to be opened for the passage of river traffic, there would be obviously great delay in the passage of these trains. If we suppose the trains to be equally divided, that is, 36 passing east and 36 going west, and that they were submitted to no delay, and the bridge were arranged for a double track, it would require, the trains following as closely as possible at a rate of 6 miles per hour, about three-quarters of an hour to cross these cars, and would not cause a very material delay to river traffic; but the practice in passing such trains is far different from this supposed case.

It is very probable, as is now the practice on the present bridge, that the passenger trains would be crossed in the morning and evening, and that the freight trains would be distributed over the remainder of the twenty-four hours. Then, if we suppose that the hours between 7 a. m. and 9 a. m. and 7 p. m. and 9 p. m. are devoted to the passenger traffic, we would have left 15 freight trains to be passed in the remainder of the twenty-four hours and very probably equally distributed over them, or about 15 trains in twenty hours; thus it would appear that there are very few hours (five) in the day during which the draw could be opened certainly without interfering with traffic.

Now, it appears that there will be at least twenty openings per day required to accommodate the regular running boats, not to speak of local harbor traffic, so that it would seem that at every hour of the day there is a great probability of delay to trains or the river commerce. Let it be supposed that it would require thirty minutes to open and close the draw and for the passage of boats—and this is not a high estimate of the time required—it would, under this supposition, require for twenty openings about ten hours, and this time would, if taken from the running time on the bridge, be a serious delay to the bridge traffic, which had only five hours to spare, as above mentioned, and would also cause a delay to boats passing the bridge of the same amount.

There may be hours, or even days, when from some accident the draw becomes impracticable. If this happens when it is open the bridge is practically, for the time being, destroyed as such and stops all traffic across it; if it occurs when the draw is shut it closes the navigation of the river for a like period.

X X 4.

GUIDING-DIKE AT THE BRIDGE OF THE PITTSBURGH AND LAKE ERIE RAILROAD ACROSS THE OHIO RIVER AT BEAVER, PENNSYLVANIA.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., January 25, 1887.

GENERAL; In sending forward herewith, as the senior member, the unanimous report of the Board of Engineers which has had under consideration the propriety of requiring the railroad company to construct a guiding-dike for one of the piers of the channel-span of their bridge over the Ohio River at Beaver, Pa., I have the honor to suggest that, if the opinion of the Board be approved, the dike be constructed under the supervision and to the satisfaction of the officer of the Corps of Engineers having in charge the improvement of the Ohio River near Pittsburgh, Pa., and that it be so arranged as to admit of an increase of its height by 3 or 4 feet, should such an increase be found necessary or expedient, of which, in my opinion, the probability is strong.

The tracings which form part of the report are sent separately to-day by mail.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Lieut. Col. of Engineers.

CHIEF OF ENGINEERS, U. S. A.

REPORT OF BOARD OF ENGINEERS.

CINCINNATI, OHIO, *January* 19, 1887.

GENERAL: The Board of Engineers constituted by Special Order No. 127. dated Headquarters Corps of Engineers, Washington, D. C. September 4, 1886, "to consider and report upon certain questions presented in connection with the construction of a guiding-dike by the Pittsburgh and Lake Erie Railroad Company" at its bridge over the Ohio River at Beaver, Pa., respectfully submits the following final report:

The Board first met at Pittsburgh on the 12th of October, and held a public session to which every one interested was invited to be present and express his views upon the questions under consideration. After a full and general discussion the Board adjourned to meet in Cincinnati October 15. The Board met according to adjournment and a prelimi-

nary report was submitted, recommending that a survey be made of the Ohio River above and below the bridge in order to ascertain what changes had taken place in the river-bed since its construction, and also that the members of the Board be authorized to visit the bridge at the next coal-boat stage of water to observe the difficulties and dangers encountered while running the bridge with tows of coal.

These recommendations were approved and the survey has been made, and the members of the Board have passed through the bridge on coal tows upon three consecutive days. The tows upon which the trips were made were of the usual size run upon this portion of the river, the largest measuring about 700 feet in length and 135 feet in width. This latter was accompanied by a second steamer, which rendered assistance in running the bridge, after which it returned to Pittsburgh.

The construction of a guiding-dike extending up-stream from the pier on the left of the channel-span of this bridge has been under discussion since the building of the bridge was first contemplated. Originally one of the conditions of the permission granted to the railroad company to place the bridge at the site selected was that a smooth guiding-dike, 300 feet long and 15 feet high, should be built up-stream from the pier mentioned inclining towards the bank. After the construction of the bridge had been commenced and the piers were in position, but before work upon the dike had been attempted, upon the earnest solicitation of the pilots, captains, and owners of the coal fleets navigating the Ohio, the conditions existing at the site were again considered. This resulted in a decision that the security of navigation required that the length of the dike be increased about 618 feet, making its total length about 918 feet. The railroad company, being notified of this decision, questiond the right of the United States to require them to build the extension at their expense, maintaining at the same time that a dike 300 feet long would be of no benefit to navigation if placed where originally located.

The successive steps that were taken during the first part of this controversy are clearly set forth in a report of a Board of Engineers submitted October 25, 1883, and printed in Appendix D D of the Annual Report of the Chief of Engineers for 1884, pages 1779 to 1786, to which reference is made.

This Board was directed to "give the subject full consideration, and report its views and recommendations as to the best method of arriving at a proper solution of the questions involved, with a view to avoiding litigation with the railroad company."

After fully considering all the questions presented to it the Board decided that "a smooth guiding-dike, 918 feet long with crest about 15 feet above low water, should be built extending up-stream from the south pier of the main channel-span to the shore at the upper extremity."

The report closes as follows:

As it is inexpedient in the interests of navigation to build a guiding-dike until means are available for giving it the full length of about 918 feet, it is recommended that the railroad company be compelled by legal process to build the whole dike, if in the opinion of the Secretary of War existing laws are sufficient for that purpose; otherwise that the subject be referred again to Congress for such action as that body may take.

Acting upon the recommendation of the Board, a suit was commenced in December, 1883, in the United States district court of western Pennsylvania, by the United States Attorney-General, to compel the company to build the dike of the increased dimensions. This finally ter-

minated in favor of the railroad company, the court deciding that the act of Congress of December, 17, 1872, under which action was brought, did not authorize the Secretary of War to change the plans of the bridge and dike after they had once been approved by him. In rendering this opinion mention was made of section 8 of the act of Congress of July 5, 1884, the provisions of which the court stated were deemed sufficient, and completely cover the case of the bridge and dike in question. The section referred to is as follows:

SEC. 8. That whenever the Secretary of War shall have good reason to believe that any railroad or other bridge now or hereafter to be constructed over any of the navigable waters of the United States, under authority of the United States or of any State or Territory, is an obstruction to the free navigation of such waters, by reason of difficulty in passing the draw-opening or the raft-span of said bridge, by rafts, steamboats, or other water-craft, it shall be the duty of the said Secretary, on satisfactory proof thereof, to require the company or persons owning, controling, or operating said bridge to cause such aids to the passage of said draw-opening or of said raft-span, or of both said draw-opening and raft-span, to be constructed, placed, and maintained, at their own cost and expense, in the form of booms, dikes, piers, or other suitable and proper structures for the guiding of said rafts, steamboats, and other water-craft safely through said opening or span, or both said opening or span, as shall be specified in his order in that behalf; and on failure of the company or persons aforesaid to make and establish such additional structures within a reasonable time, the said Secretary shall proceed to cause the same to be built or made at the expense of the United States, and shall refer the matter without delay to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in any circuit or district court of the United States in which such bridge, or any part thereof, is located, for the recovery of the cost thereof; and all moneys accruing from such proceedings shall be covered into the Treasury of the United States: *Provided*, That no greater sum than $15,000 shall be required to be expended upon any one bridge in a single year: *Provided further*, That such sum of money as may be necessary to execute the provisions of this act is hereby appropriated, out of any money in the Treasury of the United States not otherwise appropriated, to be paid on the requisition of the Secretary of War.

Under this section on April 2, 1886, the Secretary of War issued an order requiring the railroad company to construct the dike of the dimensions recommended by the Board of Engineers, and mentioned in the extract taken from their report.

In reply to this order Mr. D. T. Watson, general solicitor of the railroad company, addressed a communication to the Secretary of War dated August 10, 1886, a copy of which, with inclosures, is appended hereto. In this it is claimed that experience has demonstrated that the erection of any dike whatever in connection with the bridge would not only not improve navigation at this point but would actually obstruct it, and submits in proof of the statement two petitions, signed by captains and pilots of steamers upon the Upper Ohio River, dated, respectively, August 22, 1883, and July 1, 1886.

At the public meeting recently held in Pittsburgh, of which mention has been made, the necessity and effect of the dike were fully discussed, and it developed that the pilots and captains were much divided in their opinions as to its influence, while the coal operators and owners of the coal-tows strongly favored its construction as a necessary aid to navigation at the bridge. The conditions at the bridge, as stated by the latter, are as follows:

The channel span of the bridge is but 425 feet in the clear, and the width of many of the coal tows is sufficient to occupy nearly one-third of this opening in passing the bridge. In approaching the bridge with a tow they are obliged to follow the channel where the river makes an angle of nearly 90 degrees, the bend extending to within a short distance of the bridge. Where this terminates, the tow begins to feel the effect of the cross-currents from Beaver River, which enters the Ohio at this point. These vary in strength from time to time with the amount of water flowing from the river, and the effect produced by them depends upon the height of the water in the

Ohio River, and the direction and strength of its currents which change with the d ferent stages of water.

The principal difficulty encountered in this locality is to get the tow into positi for passing through the channel span in the short distance available after making t bend above the bridge and to allow for the drift resulting from the combination the currents of the two rivers. In running large tows a deviation of their width either side of the middle of the span brings them against one or the other of the pie Navigation at the bridge is also somewhat complicated by a quick turn to the rig being necessary as the boats leave the channel-span. With the guiding-dike c structed as proposed they believe there would be no danger of coming in contact w the left channel pier, the one now most feared. They regard the possibility of a s blow upon the dike with little apprehension, and are of the opinion that the c struction of the dike will not materially strengthen the currents with which t empty tows passing up-stream will have to contend.

In reply to the letters addressed by the Board to the Pittsburgh C Exchange, to the general manager of the railroad company, and to t Steam-boat Officers' Protective Association, referred to in the prelin nary report, communications have been received containing as far as pr ticable the information asked for. These are appended to the repo

In the statement of the Coal Exchange, it is shown that during t past nine years the annual shipments of coal have been from 2,300,0 to 4,172,000 tons, and that the loss during this period occasioned by t bridge, so far as is shown by the incomplete records that have be kept, amounts to about $40,000. The names of several coal operato who have also sustained losses are given, the amount of which is not i cluded in the sum mentioned. By reference to the letter of the gene manager of the railroad it will be observed that there have been oth losses at the bridge not mentioned by the Coal Exchange. It is a noted from these two letters, that the losses have not been confined to t years when the bridge was first built, but that they extend over the e tire period it has been in existence. It is highly probable that t amount of coal lost at this bridge would have been much greater but f the precaution that is now taken by some of the coal owners of sending second steamer with the larger coal fleets to assist them in passi through it.

The reply of the Steam-boat Officer's Protective Association conta a resolution in favor of the construction of the dike of the dimensio proposed. This association is composed largely of Ohio River stea boat captains and pilots. The resolution was almost the unanimo expression of that body, there being but three dissenting votes.

The survey of the Ohio River in the vicinity of the bridge request in the preliminary report was recently made during a low stage of wat A tracing of this is inclosed. In 1876, to comply with the act of D cember 17, 1872, the railroad company submitted a survey of the riv showing the location of the then proposed bridge. For convenience comparison, the soundings contained in this survey have been reduc by 10 feet the difference between the heights of the water at the tim of the surveys as near as could be ascertained. A tracing of the su vey thus reduced is also inclosed.

By examining these tracings it will be seen that the latter one giv a wider channel, and the shoals generally lower than the one made the higher stage of water. This is readily accounted for by the fa that in the Ohio River the scour upon the bottom is as a rule greater the water falls to the level of low water than at other times. The mo notable change discovered by the last survey is the formation of a b near the left-hand channel pier of the bridge, which partly obstruc the low-water channel between the piers. It is now 4 feet above l water, and extends nearly 60 feet from the left-hand pier directly acro

the channel. Should this shoal continue to increase it is probable that it will become a serious obstacle to navigation.

After carefully considering all the questions brought before it, together with all the information obtained, the Board is of the opinion that it is important to the interests of navigation that the dike should be constructed as designed. It is considered to be not only necessary as an aid to the coal tows passing the bridge, but also as a check to the future growth of the shoal now partly closing the water-way of the channel-span, and threatening to become a material obstruction.

The Board, therefore, recommends that the order of the Secretary of War issued April 2, 1886, be enforced, and that the railroad company be required to build the dike 918 feet long and 15 feet high extending up-stream from the left hand channel-pier.

Respectfully submitted.

WM. P. CRAIGHILL,
Lieut. Col. of Engineers.
A. MACKENZIE,
Major of Engineers.
JAS. C. POST,
Major of Engineers.

Brig. Gen. JAMES C. DUANE,
Chief of Engineers, U. S. A.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 31, 1887.

SIR: Referring to the letter of D. T. Watson, esq., general solicitor of the Pittsburgh and Lake Erie Railroad Company, dated August 10, 1886, requesting the War Department to refer the question as to the expediency of building a guiding dike 918 feet up-stream from the left-hand channel-pier of the bridge over the Ohio River, at Beaver, Pa., as directed by the order of the Secretary of War issued April 2, 1886, to a Board of Engineers; and to the report of this office indorsed thereon, dated August 17, and approved August 18, 1886, I have now the honor to submit the report of the Board appointed to consider the subject, and to invite attention thereto.

The Board, as will appear from its report, has given the subject the fullest and most careful consideration, and after consultation with the commercial bodies of Pittsburgh and parties interested in the navigation of the Ohio River, and personal investigation, by passing the bridge on coal tows for three consecutive days, has reached the following conclusions:

> After carefully considering all the questions brought before it, together with all the information obtained, the Board is of the opinion that it is important to the interests of navigation that the dike should be constructed as designed. It is considered to be not only necessary as an aid to the coal tows passing the bridge, but also as a check to the future growth of the shoal now partly closing the water-way of the channel-span, and threatening to become a material obstruction.
>
> The Board therefore recommends that the order of the Secretary of War, issued April 2, 1886, be enforced, and that the railroad company be required to build the dike 918 feet long and 15 feet high, extending up-stream from the left-hand channel-pier.

The conclusions of the Board are concurred in by this office.

In connection with the subject I beg also to invite attention to the letter of the 25th of January, from Col. W. P. Craighill, Corps of Engineers, the senior member of the Board, and to the suggestion contained therein, which is also concurred in, viz:

That if the opinion of the Board be approved the dike be constructed under the supervision and to the satisfaction of the officer of the Corps of Engineers having in charge the improvement of the Ohio River near Pittsburgh, Pa., and that it be so arranged as to admit of an increase of its height by 3 or 4 feet, should such an increase be found necessary or expedient, of which, in my opinion, the probability is strong.

Previous papers herewith.

Very respectfully, your obedient servant,

J. C. DUANE,
Brig. Gen., Chief of Engineers.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.

[First indorsement.]

WAR DEPARTMENT, *February* 9, 1887.

The recommendations of the Board of Engineers are approved, and these papers are respectfully referred to the Acting Judge-Advocate-General for report whether it will be necessary to file a new notice with the company, containing the recommendations of the Board and Colonel Craighill.

By order of the Secretary of War.

JOHN TWEEDALE.
Chief Clerk.

[Second indorsement.]

WAR DEPARTMENT,
JUDGE-ADVOCATE-GENERAL'S OFFICE
Washington, D. C., February 11, 1887.

Respectfully returned to the Secretary of War.

"The question as to the expediency of building a guiding-dike 918 feet up-stream from the left-hand channel-pier of the bridge over the Ohio River at Beaver, Pa.," having, at the request of the Pittsburgh and Lake Erie Railroad Company, by its general solicitor, D. T. Watson, esq., been referred by the Secretary of War to a Board of Engineers, the question as to the necessity of a guiding-dike of such dimensions has, in my opinion, been re opened. And inasmuch as the report of said Board of Engineers is adverse to the railroad company, it is believed that it will be necessary to file with the company a new notice showing the conclusions and recommendations of the Board and the adoption and approval of the same by the Secretary of War.

G. NORMAN LIEBER,
Acting Judge-Advocate-General.

[Third indorsement.]

WAR DEPARTMENT, *February* 17, 1887.

Respectfully returned to the Chief of Engineers to draw up a form of a new notice to be served on the Pittsburgh and Lake Erie Railroad Company by the Secretary of War, in accordance with the preceding recommendation of the Acting Judge-Advocate-General.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 4, 1887.

Respectfully returned to the Secretary of War, with form of new notice prepared in compliance with preceding instructions.

J. C. DUANE,
Brig. Gen., Chief of Engineers.

[Fifth indorsement.]

WAR DEPARTMENT, *March* 16, 1887.

Respectfully returned to the Chief of Engineers, with the notice that has been approved by and received the signature of the Acting Secretary of War.

The Chief of Engineers will cause proper service of this notice to be made upon the Pittsburgh and Lake Erie Railroad Company by an officer of the Corps of Engineers.

By order of the Acting Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

[Sixth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
April 4, 1887.

Respectfully returned to the Secretary of War, with letter of Lieut. Col. W. E. Merrill, Corps of Engineers, dated March 30, 1887, reporting personal service by him March 29, 1887, of the notice of the Secretary of War dated March 16, 1887, requiring the Pittsburgh and Lake Erie Railroad Company to construct in the interests of navigation a guiding-dike at their bridge across the Ohio River at Beaver, Pa., and inclosing acknowledgment of the service in behalf of the company by W. C. Quincy, its general manager, dated March 29, 1887, by whom it was received.

J. C. DUANE,
Brig. Gen., Chief of Engineers.

[Seventh indorsement.]

WAR DEPARTMENT, *April* 7, 1887.

Seen by the Secretary of War. File.

By order of the Secretary of War.

SAM'L HODGKINS,
Acting Chief Clerk.

X X 5.

BRIDGE ACROSS THE WILLAMETTE RIVER AT OR NEAR THE CITY OF PORTLAND, OREGON.

UNITED STATES SENATE,
Washington, D. C., December 9, 1886.

SIR: I am directed by the Committee on Commerce to refer to you the inclosed bill (S. 2904) to authorize the construction of a bridge

across the Willamette River at Portland, Oregon, and to request you to furnish the committee with such suggestions as you may deem proper touching the merits of the bill and the propriety of its passage.

Very respectfully,

J. B. McMillan,
Clerk.

Hon. William C. Endicott,
Secretary of War.

[First indorsement.]

Office Chief of Engineers,
U. S. Army,
March 1, 1887.

Respectfully returned to the Secretary of War with copy of the Report of the Board of Engineers constituted by orders from this office to consider and report upon the question of the construction of the bridge across the Willamette River, at Portland, Oregon, mentioned in Senate bill 2904, Forty-ninth Congress, second session, to which attention is invited.

The Board has given the subject careful and intelligent consideration, and its views are concurred in by this office.

The recommendations of the Board are embodied in the proposed substitute for Senate bill 2904, now under consideration, and are recommended for adoption.

J. C. Duane,
Brig. Gen., Chief of Engineers.

LETTER OF INSTRUCTIONS TO BOARD OF ENGINEERS.

Office of the Chief of Engineers,
United States Army,
Washington, D. C., December 16, 1886.

Sir: The inclosed letter to the Secretary of War, from the Committee on Commerce of the United States Senate, with accompanying Senate bill 2904, a bill "To authorize the construction of a bridge across the Willamette River at Portland, Oregon," is transmitted for the information of the Board of Engineers constituted by Special Orders, No. 195, Headquarters Corps of Engineers, dated December 16, 1886, of which you are the presiding officer.

It is desired that the Board make full investigation of the subject, and submit its report with recommendations at the earliest practicable period consistent with a proper consideration of the questions involved.

An additional copy of the bill is also inclosed, with request that the Board indicate upon it any amendments, etc., that it may deem it advisable to propose.

By command of Brigadier-General Duane.

Very respectfully, your obedient servant,

John G. Parke,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

Maj. W. A. Jones,
Corps of Engineers.

REPORT OF BOARD OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oregon, February 14, 1887.

SIR: The Board of Engineers, convened by Special Orders, No. 195, Headquarters Corps of Engineers, December 16, 1886, to examine and report upon the bridge across the Willamette River at Portland, Oregon, as authorized by Senate bill 2904, Forty-ninth Congress, second session, to be built by the Willamette River Bridge Company, has the honor to submit the following report:

Portland, on the west bank of the Willamette River, is a river seaport, situated on tide-water, 110 miles from the sea. It is also the center of interior water-ways. Opposite are the city of East Portland and the towns of Albina and Sellwood; adjacent are the river towns of Oregon City and Oswego, Saint John's and Vancouver.

Portland and East Portland form a center for a number of railroad lines or divisions.

One of the Willamette Valley lines and all of the transcontinental lines that reach this section terminate on the east side of the river. On the west side are other Willamette Valley roads and a road to Puget Sound points.

Passengers are now transferred by ferry and freight cars by means of inclines and a barge. This method is inconvenient on account of the variable stage of the river and at times on account of the strong current. At present the transfer facilities are insufficient and cause a large tax on freights, and much freight has to be hauled to and from the east side on trucks at a large expense. The transfer facilities could readily be increased, but after all it is almost necessary for the interests of commerce that the railroads centering here should join their tracks. All of the transcontinental rail traffic and much of the real traffic between Portland and its own territory is obliged to cross the river, and when in competition with other points it is a serious injury to both Portland and the country tributary to it to be subjected to the delay and expense which the present method and means of transfer across the river imposes upon their commerce.

Furthermore, with the increase in population of the towns upon the east side and of the country behind them, highway connections are also needed and preferably near the middle of the harbor.

A tunnel is not practicable; neither is a high bridge. A low bridge with a draw opening is the only means for giving the fullest facilities to traffic across the river.

The Willamette River to Portland is open to and navigated by log-rafts, barges, ferries, river steamers, and sea-going vessels. Portland is the nearest deep tide-water port to a large extent of very productive country lying to the east and south of it. The river approach is navigable at all seasons for vessels with a draught of 18 feet, and for much of the year is open for vessels with a greater draught. It can readily be improved to accommodate at all stages vessels with a draught of 24 feet. The harbor and wharves of Portland accommodate at all seasons vessels with a draught of 20 feet.

The harbor is formed by the Willamette River flowing north between the cities of Portland and East Portland. The river makes two bends in the harbor, the sharpest bend being at the narrowest point of the river. It is subject to high freshets, strong and variable currents, heavy drift, and dense fog. The influence of the tide wholly disappears at about half a river rise.

Rises in the river are of two classes. One, occurring during the fall and winter, is due to Willamette River freshets and produces strong currents with, at times, heavy drift. The other, occurring regularly in June, is due to Columbia River freshets and produces slackwater.

A harbor comprises (1) wharf room, (2) anchorage-ground, and (3) thoroughfare.

The deep-water frontage in this harbor has a length of about 17,000 feet on the Portland side and about 12,000 on the East Portland side, a total of 29,000 feet. While the wharf room is thus extensive, an examination of the chart shows that the thoroughfare is narrow and with any large increase of commerce must become much crowded. It also shows that the anchorage-ground for large ships is very limited.

The distances from about the middle of Ross Island, the natural head of the harbor, down-stream to the principal points on the river front, and the widths at these points between low-water marks and between 18-foot curves, are given in the following table:

Location.	Distance from head of harbor.	Width at low water.	Width between 18-foot curves.
	Feet.	*Feet.*	*Feet.*
Middle of Ross Island	0	600	25
Thence to foot of Ross Island	3,000	650	50 to 475
Opposite Hall street	6,000	1,650	400
Opposite Market street	7,300	1,800	450
Opposite Columbia street	7,800	1,850	600
Thence to Morrison street	9,750	1,750 to 1,400	450
Opposite Washington street	10,250	1,240	400
Opposite Pine street	11,000	1,000	550
Opposite A street	11,750	900	800
Opposite E street	12,750	1,200	1,000
Opposite I street	14,000	600	600
Opposite Weidler's Mill	17,650	1,400	650
3,000 feet below Weidler's Mill*	20,650	1,800	850
Across Swan Island Bar, opposite dry dock	23,200	2,200	....

* Here the deep-water harbor terminates and a narrow channel extends northward.

The limited capacity of the harbor is evident from these figures. With the increase in river traffic which may be expected if the growth of the past be continued in the future, this harbor must necessarily be very much crowded, and it is difficult to see how any bridge, and, more especially, one located in the lower part of it, can be so handled as not to be a great obstruction to the free navigation of the river, or to cause great delays to the cross river traffic, or both.

Owing to the swift currents and dense fogs, which at times prevail, any bridge in this harbor, no matter what the width of the draw-openings, must be an obstruction. While a bridge across the approaches to a harbor may not be a material obstruction to navigation and may not cause serious injury to the harbor itself, a bridge through the middle of a harbor is inadmissible. The following extracts from the opinions of the judges of the United States circuit court for the district of Oregon in the case of the Morrison Street Bridge are to the point:

Upon the evidence and in the very nature of things, there can be no doubt that this bridge, where (Morrison street) * * * it is being constructed, is a serious obstruction to the navigation of the river.

* * * * * * *

Indeed, the further investigation of this matter makes it appear very probable to my mind that no bridge, unless it be a suspension one, can be constructed over the river at this point, without being a serious obstruction to its navigability and impairing its usefulness as a common highway for the citizens of the United States.

The Willamette River in front of Portland is not only a navigable stream with a ship-channel, it is also a sea-port. The harbor, as I have before said, of the emporium and financial center of the Northwest, and to all appearance, on the Pacific coast, save one.

Probably nine-tenths of the exports produced west of the Rocky Mountains and north of the forty-second parallel are gathered here for sale and shipment abroad upon sea-going vessels of, in some cases, 3,000 tons burden.

Every bushel of grain grown for export over this vast region, and particularly in the great Willamette Valley, feels the cost of storage and dockage at this port, and anything which limits or restricts the capacity or convenience of its harbor works a direct injury to a great body of the producers throughout the country.

* * * * * * *

The river is navigable water of the people of the United States and the harbor is for the free use of all people whose exports and imports freight the vessels that frequent it from all parts of the world.

Located as it is right in the midst of the harbor, where vessels are required to move constantly from place to place, without a passage, except at the single point of this draw, the bridge will be a serious obstruction to navigation in the harbor, even if the draw was sufficient for the passage of vessels up and down the stream.

The act of Congress does not limit the free navigation of the river to a particular part or channel, but it declares the whole river a free and common highway to the full extent of its capability of navigation.

A bridge may not be a material obstruction to the navigation of a river if erected at a point where vessels simply pass up and down the channel on their way to and from port. But in the case of a harbor like this, the location, surroundings, and circumstances must be considered, and they may require that no part of it be obstructed or closed to navigation. In this view of the matter I think that any bridge in this harbor would necessarily be such an obstruction to its navigation as to require the consent of Congress to justify it.

* * * * * * *

This harbor is not large, and when the shipping here is much increased, as it doubtless will be with the growth of the country and the place, there will be no room to spare in it.

* * * * * * *

All these things are to be considered in determining whether it is good policy even if Congress could be brought to consent to it, to bisect this harbor with a bridge that would render it unnavigable along its line, except at a single point.

Under date of December 1, 1880, Mr. Henry Villard, president of the Oregon Railway and Navigation Company, the corporation really concerned in building the bridge to be authorized by this act, made, on the part of his company, a protest to the Secretary of War against the building of the Morrison Street Bridge, from which the following extracts were taken:

That such location, it will be observed, is about the center of the city front, and at such a point as to necessarily create a most serious obstruction to the shipping of the city on at least one-half the city's river front.

* * * * * * *

That the construction of a bridge at the point designated would seriously interfere with the navigation of said river, and the commercial interests of the city of Portland, the State of Oregon, and the commerce of the Pacific Ocean, centering there as well. * * * No matter how carefully provided with draws, such bridge, will, in the judgment of this company and those interested in the navigation of said river, and the commerce of said port, prove to be at all seasons of the year a serious obstruction to navigation, affecting materially and adversely its shipping both above and below the proposed bridge. And at times of high water this obstruction will be so serious as to prevent the passage of sea-going vessels, at least without great danger. The current of the river at and above the site of the proposed bridge in times of high water is unusually swift; this, with the want of room to enable vessels to swing before entering the draw, would constitute a bridge as little else than an impassable barrier to navigation above it by ocean vessels. * * *

The construction of a bridge in the middle of this harbor would practically place the head of the harbor at that point, as few sea-going vessels would pass through it, but all would seek wharfage and anchorage room below it. This is conclusively shown by the effect of the Morrison Street Bridge now constructing. Very few pilots will attempt to

tow a ship through this bridge, and the owners of a majority of the tow-boats have forbidden their boats to do so. Even river steamers that formerly had landings above this bridge have removed them to points below it.

Necessarily, with the increase of shipping at this port, the loss in harbor room by the practical extinction of that portion above a bridge must be compensated for by the production of artificial harbor-room below it at a great cost that must be borne by the producers who ship from this port. Such a tax should not be permitted when, by a not too great outlay, the railroad connection can be otherwise made. As in all cases of bridging navigable streams for railroads, a compromise between the navigation interests and the railroad interests must be made.

The desired location for the bridge to be authorized by this act is at the foot of I street.

On the 7th instant, under telegraphic instructions from the Chief of Engineers, the Board furnished an abstract of its views to the Hon. Sylvester Pennoyer, governor of Oregon, who had at the time under consideration a bill of the Oregon legislature authorizing the same bridge as that before the Board.

A copy is transmitted herewith. This act does not regulate the plan of the bridge except as to the draw openings, requiring them to be not less than 150 feet, and has been passed, notwithstanding the governor's veto.

The proposed location is near the middle of the lower part of the harbor, and though the most convenient and least expensive for the railroad interests, is not judicious so far as navigation interests are concerned. It is immediately below a sharp bend and at the narrowest part of the harbor. Currents of 6 miles an hour have been measured in a wider section of the river above this point, and it is safe to assume that at stages of 20 feet they will reach 8 miles in this narrow throat. The river section, only 600 feet in width, and already too contracted for the ready escape of flood waters, would be reduced in area nearly 10 per cent. by the piers of the proposed bridge. There must result from such a reduction considerably increased velocities at all depths, because at stages above about 12 feet, the confines of the river are the vertical warehouse walls on one side and a nearly vertical bank on the other. At these stages the volume of water increases faster than the hydraulic mean depth, and this reduction in section would still further increase the damming effect and its consequent velocities, especially those on the bottom and sides. The effect on the regimen of the river and on the channel and harbor above and below at points already shoal, might be considerable.

Also, above this location the total deep-water frontage amounts to 17,600 feet, a greater part of which lies on the Portland side, while below it this frontage amounts to but 11,500 feet, a greater part of which lies on the East Portland side. Most of the shipping from this port now is, and probably will continue to be, from points below I street, but, notwithstanding this fact, the large extent of deep-water frontage above that point should not be practically destroyed by a bridge, when this frontage may be required in the future and when the railroads can cross at other points.

The movement of the shipping interests down the stream was started by a large fire in South Portland, but received an additional impetus from the beginning of the construction of the Morrison Street Bridge.

As a compromise between the desired location at I street and the natural head of the harbor at Ross Island, the Board suggests the foot of

Market street, and recommends that no bridge be authorized within the limits of the harbor of Portland below that point. This point is but 500 feet above Columbia street, the location that was approved for a bridge by a Board of Engineers in 1872. A draw opening of 160 feet in the clear at low water would here be sufficient for the river traffic at this point. Connections can be made on the east side, and all the railroad lines entering the city would be afforded an opportunity of reaching the general terminal grounds in North Portland, with which also connections could be made by several routes, preferably by a tunnel which would be through earth, and not to exceed 5,000 feet in length, and thence for half that distance through an unimportant street and in part below its level. A bridge at this point, though much longer than at the desired location, would be built in shoaler water and with shorter spans, and would be favorably located for highway traffic.

Locations for a bridge are also available below the harbor or in the extreme lower part of it. Such a location was selected by the Northern Pacific Railroad Company for a bridge with draw openings of about 171 feet in the clear at low water. Construction of this bridge was commenced, but was discontinued, and all piling was removed. Any bridge authorized below the harbor should have draw openings of not less than 200 feet in the clear at low water.

The Board recommends that any bridge authorized at or near Portland should be made to conform to the following requirements:

That no location within the limits of the harbor shall be adopted below Market street.

That the width of the draw openings in the clear at low water shall not be less than 160 feet for any bridge at or above Market street, and shall not be less than 200 feet for any bridge below the harbor.

That the draw openings shall be provided with sheering or other facilities for working boats through by lines.

That one, at least, of the spans adjacent to the draw-span shall not be less than 300 feet in the clear at low water.

That the lowest part of the superstructure shall not be less than 10 feet above the highest known stage due to the river's own freshets, and that the piers shall be placed parallel to the current at mean high stages, due to the same freshets.

That no riprapping or other filling or projections around the piers shall materially reduce the water-way between them.

That in case a draw-opening be next to either bank, the right of wharfage on that bank shall be extinguished for 700 feet above and 700 feet below the bridge.

That upon reasonable signal, the draw shall be opened promptly for the passage of boats, and that the company owning the bridge shall maintain at its own expense good and sufficient light and fog-signals under direction of the Light-House Board.

That the erection of the bridge shall not be commenced until the plan and location of the same shall have been approved by the Secretary of War.

That the right to use the bridge shall be assured to such railroad companies as may desire to use it, under proper regulations and upon payment of proper sums.

The recommendations of the Board are embodied in the draught of a substitute for Senate Bill 2904, Forty-ninth Congress, second session, forwarded herewith.

The Board wishes to explain that the Morrison Street Bridge, now in course of construction and before the United States courts as to its

legality, has formed no basis or guide for the recommendations herein.

Following is a brief summary of bridges authorized, or whose construction has been commenced, at Portland:

(1) Congress, by act of February 2, 1872, authorized the city of Portland to construct a highway bridge at the foot of Columbia street. The plan of this bridge was examined and reported upon by a Board of Engineers and approved with only some slight modifications, but the bridge was never built, the act expiring in six years by limitation.

(2) Congress, by act of June 23, 1874, authorized the Oregon and California Railroad Company or the Oregon Central Railroad Company to construct a bridge at Portland, but nothing was ever done under the act.

(3) The legislature of Oregon, by act of October 18, 1878, authorized the Portland Bridge Company to build a highway bridge at the foot of Morrison street.

The construction of this bridge was commenced in 1880, but on a hearing before the United States circuit court for the district of Oregon the work of construction was enjoined and the case is now before the Supreme Court. In the summer of 1886, however, the construction of this bridge was recommenced, and is now being pushed to completion.

(4) Under the provisions of its act of incorporation, the Northern Pacific Railroad Company commenced the construction of a bridge in the extreme lower part of the harbor of Portland. The building of this bridge was discontinued, and the piling driven for piers has since been removed.

Very respectfully, your obedient servants,

W. A. JONES,
Major of Engineers.
CHAS. F. POWELL,
Captain of Engineers.
EDW. BURR,
First Lieut. of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

LETTER OF THE BOARD OF ENGINEERS TO THE GOVERNOR OF THE STATE OF OREGON.

PORTLAND, OREGON, *February* 7, 1887.

SIR: Under instructions from the Chief of Engineers, U. S. Army, we have the honor to submit to you the following remarks upon the proposed bridge at I street, across the Willamette River at Portland:

The location is not, in our judgment, judicious, for the following reasons. It is at the narrowest point in the harbor, where the hydraulic conditions are such that the water-way is already too small for the discharge at high stages. The introduction of bridge piers at this point would have a bad effect upon the regimen of the river, and might injure or destroy valuable portions of the harbor and ship-channel. Furthermore, the location is not adapted to a draw of sufficient width, and the bridge would practically form the head of a harbor already limited in capacity.

From this point to the natural head of the harbor, at Ross Island, the deep-water frontage has a length of 14,000 feet on the Portland side, and about 3,600 feet on the East Portland side. Below it there is a length of 8,500 feet on the East Portland side and not exceeding 3,000

feet on the Portland side. Above this point lies a considerable stretch of wide and deep river. To terminate the harbor at this point would necessitate the forming of a new harbor below it, at a considerable cost in the first place, and a continuous cost for dredging for maintenance thereafter. This would entail a serious tax upon the commerce of the port.

The Board has further to remark that whatever location should be adopted the law should require:

(1) That the piers of the bridge be parallel with the current at mean high-water stages due to the river's own freshets.

(2) That the clear headway under the said bridge should be at least 10 feet at the highest known stage due to the same freshets.

(3) That if the draw-span be adjacent to either bank the right of wharfage on that bank should be extinguished for a distance of at least 700 feet above and 700 feet below the bridge; this for the purpose of insuring a free and unobstructed approach to the shore-opening.

(4) That rest-piers should be provided above and below the pivot-pier, with suitable filling between them, and also other accessory structures as may be needed for the safe passage of vessels.

(5) That the company operating the bridge shall maintain at its own expense good and sufficient light and fog-signals, and open the draw for the passage of vessels promptly upon reasonable signal.

(6) That no riprapping or other filling, or projections around the piers, shall materially reduce the water-way between them.

Should the location at I street be approved, the law should require that the tracks cross Front street with a clear headway of 14 feet; otherwise the minimum height of the bridge above the river would necessitate the crossing of this street at a height which would seriously obstruct the said street at a point where the wagon traffic is heavy and which it can not conveniently avoid, because the adjacent streets are vacated.

In conclusion, the Board begs to state that the two lines of traffic along the harbor and across it can hardly exist without serious concessions by each, and that a fair compromise would be the surrender of the part of the harbor above Market street. A bridge at this point or above could connect with the North Portland terminal grounds by different practicable routes and form a junction for all the railroads centering at Portland. Draw-openings at this point could be 160 feet wide.

Another alternative location for a railroad bridge, considerably below the harbor, would be at Saint John's, where the draw-openings should be at least 200 feet wide.

We have the honor to be your very obedient servants,

W. A. JONES,
Major of Engineers.
CHAS. F. POWELL,
Captain of Engineers.
EDW. BURR,
First Lieut. of Engineers.

Hon. SYLVESTER PENNOYER,
Governor of Oregon, Salem, Oregon.

AN ACT to authorize the construction of a bridge over the Willamette River at or near the city of Portland, Oregon, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Willamette Bridge Company, a corporation duly and legally incorporated under and by virtue of the laws of the

State of Oregon, its assigns or successors, to construct and maintain a bridge and th approaches thereto over the Willamette River at or near Portland, in the State c Oregon. Said bridge shall be constructed to provide for the passage of railway train and at the option of the parties by whom it may be built, may be used for the passag of wheel and foot traffic of all kinds, for such reasonable rates of toll as may be deter mined and regulated by the proper authorities of the State of Oregon.

SEC. 2. That any bridge built under this act and subject to its limitations shall b a lawful structure, and shall be recognized and known as a post-route, upon whic no higher charge shall be made for the transmission over the same of the mails, th troops, and the munitions of war of the United States, or passengers or freight passin over said bridge, than the rate per mile paid for the transportation over the railroad or highways leading to the said bridge; and it shall enjoy the rights and privilege of other post-roads in the United States.

SEC. 3. That the said bridge shall be constructed as a pivot draw-bridge with draw openings placed over a good and sufficient channel of the river: *Provided*, That sai draw opening shall be not less than 160 feet in width in the clear at extreme low water stage, if the bridge be located at or above Market street, Portland; and shal be not less than 200 feet in width in the clear at extreme low-water stage if the bridg be located below the limits of the harbor of Portland; and that the opening or pas sage-way shall be so provided and equipped with sheering facilities that water craf may be worked through by lines when necessary or desirable: *Provided also*, Tha one at least of the adjacent side spans shall be not less than 300 feet in width in th clear at extreme low-water stage: *Provided also*, That the lowest part of the super structure of the bridge shall be not less than 10 feet above the highest known stag due to the river's own freshets, and that the piers of the bridge shall be placed par allel with the current at mean high stages due to the same freshets: *Provided also*, That no riprapping or other filling or projections around the piers shall materiall reduce the water-way between them: *Provided also*, That in case the said bridg be built with a draw opening next to either bank of the river, the company con structing the same shall extinguish the right of wharfage on that bank for dis tance of 700 feet above and 700 feet below the bridge: *Provided also*, That, upon reasonable signal, the draw of said bridge shall be opened promptly for the passag of water craft of all kinds, and said company or corporation shall maintain, at it own expense, good and sufficient light and fog signals under the direction of th Light-House Board: *And provided further*, That no bridge constructed under thi act shall be located below Market street and within the limits of the harbor of th city of Portland. No bridge shall be erected or maintained under the authority o this act which shall at any time substantially or materially obstruct the free navi gation of the said river, and if any bridge erected under such authority shall, in th opinion of the Secretary of War, obstruct such navigation, he is authorized to caus such change or alteration of said bridge to be made as will effectually obviate such obstructions, and all such alterations shall be made and all such obstructions be re moved at the expense of the owner or owners of said bridge, and in case of any liti gation arising from this procedure or from any obstruction or alleged obstruction to the navigation of the said river, caused by said bridge or resulting from a non-com pliance with this act, the case may be brought in the district court of the United States of the State of Oregon: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in refer ence to the protection of the navigation of rivers or to exempt this bridge from the operations of the same.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon payment of reasonable compen sation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use, shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties.

SEC. 5. That any bridge authorized to be built under this act shall be built and lo cated under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe. And to secure that object, the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, including the piers and accessory structures, and a map of the location, giving for a space of one-half mile above and one-half mile below the proposed location the topography of the banks of the river, the shore-lines at high and low water, the direction and strength of the currents at mean high stages due to its own freshets, soundings sufficient in number to accurately delineate the bed of the stream by curves differing by 6 feet, and the location of any other bridge or bridges; and shall furnish such other information as may be necessary for a full and complete understanding of the subject; and until the said plan and

location are approved by the Secretary of War, the erection of the bridge shall not be commenced, and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

SEC. 6. That the United States shall have the right of way for such postal telegraphic lines across the said bridge as the Government may construct or own.

SEC. 7. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal at the expense of the owners thereof, whenever Congress shall decide that the public good requires it, is also hereby expressly reserved.

LETTER FROM THE SECRETARY OF WAR TO THE CHAIRMAN OF THE COMMITTEE ON COMMERCE OF THE UNITED STATES SENATE.

WAR DEPARTMENT,
Washington City, March 3, 1887.

SIR: I have the honor to acknowledge the receipt of the letter of the 9th of December last from the clerk of your committee inclosing, for the views of the Department, Senate bill No. 2904, "to authorize the construction of a bridge across the Willamette River at Portland, Oregon."

In reply, I beg to inclose a copy of the report of the 14th ultimo of the Board of Engineers appointed to consider the question of the construction of this bridge.

The Chief of Engineers states that the Board have given the subject careful and intelligent consideration, and that he concurs in their views.

The recommendations of the Board are embodied in the accompanying draught of a substitute for Senate bill 2904, and are commended by the Chief of Engineers for adoption.

The bill is herewith returned.

Very respectfully, your obedient servant,

WILLIAM C. ENDICOTT,
Secretary of War.

Hon. S. J. R. MCMILLAN,
Chairman Committee on Commerce, U. S. Senate.

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RAILWAY BRIDGE ACROSS RED RIVER AT SHREVEPORT, LOUISIANA.

WAR DEPARTMENT,
Washington City, March 1, 1887.

The Secretary of War has the honor to transmit to the House of Representatives a letter of the 25th instant from the Chief of Engineers, together with a report and accompanying papers from Capt. J. H. Willard, Corps of Engineers, which will, it is believed, afford the information called for by House resolution of the 11th ultimo, as follows:

Resolved, That the Secretary of War be requested to inform the House what steps, if any, have been taken to cause the removal of the sand-bar which has formed against the piers of the Vicksburg, Shreveport and Pacific Railway Bridge spanning the Red River at Shreveport, La., and which for more than six months has entirely prevented the passage of boats through the draw of said bridge on a river navigable 300 miles above and 500 miles below the bridge.

Resolved further, That the Secretary inform the House whether or not the Department holds that it is the duty of said railway company to remove said obstruction, and if so, what demand to do so has been made upon said company, when made, and their reply, and what steps, if any, have been taken to enforce the demand.

Resolved further, That the Secretary inform the House what steps the Department proposes to take to cause the removal of said obstruction.

It will be seen from the accompanying report that the attention of the president of the Vicksburg, Shreveport and Pacific Railway Company was, under date of July 13, 1886, called to the fact that the bridge in question was obstructing the navigation of the Red River. A response was received from him July 26, 1886 (copy herewith), stating that he had instructed the chief engineer of the company to examine into the matter at once and report to him in full, which would, in due course, be submitted to the Engineer Department. Nothing further on the subject has been received from him, but the inclosed report shows that examinations of the bridge and river have been in progress preparatory to action.

Section 8 of the river and harbor act of July 5, 1884, provides:

And on failure of the company or persons aforesaid to make and establish such additional structures within a reasonable time, the said Secretary shall proceed to cause the same to be built or made at the expense of the United States, and shall refer the matter without delay to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in any circuit or district court in the United States in which such bridge or any part thereof is located, for the recovery of the cost thereof.

The reasonable time mentioned in the act is deemed now to have elapsed during which the company should have taken some steps in the matter, and its provisions will therefore be carried into effect without further delay.

WILLIAM C. ENDICOTT,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 25, 1887.

SIR: I have the honor to return herewith the resolution of the House of Representatives dated January 11, 1887, which was referred to this office, requesting the Secretary of War "to inform the House what steps, if any, have been taken to cause the removal of the sand-bar which has formed against the piers of the Vicksburg, Shreveport and Pacific Railway Bridge spanning the Red River at Shreveport, La.," and to state that the resolution was referred to Capt. J. H. Willard, Corps of Engineers, January 13, 1887, a copy of whose report thereon, dated February 17, 1887, is herewith submitted. Captain Willard gives a full history of the matter so far as regards the action of this office and of the railway company, which it is hoped will prove satisfactory. Captain Willard states that "it is safe to say that navigation through the draw-opening is now impracticable at any stage less than 5 feet above low water."

In regard to the clause of the resolution "that the Secretary inform the House whether or not the Department holds that it is the duty of

said railway company to remove said obstruction; and, if so, what demand to do so has been made upon said company, when made, and their reply; and what steps, if any, have been taken to enforce the demand," I beg to say that under the provisions of section 8 of the river and harbor act of July 5, 1884, the attention of the president of the Vicksburg, Shreveport, and Pacific Railway Company was, under date of July 13, 1886, called to the fact that the bridge was obstructing the navigation of the Red River, as will appear from the accompanying report of Captain Willard, and a response was received from him July 26, 1886 (copy herewith), stating that he had instructed the chief engineer of the company to examine into the matter at once and report to him in full, which would, in due course, be submitted to this office. Nothing further has been received from him.

Section 8 of the act above referred to provides "and on failure of the company or persons aforesaid to make and establish such additional structures within a reasonable time, the said Secretary shall proceed to cause the same to be built or made at the expense of the United States, and shall refer the matter without delay to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in any circuit or district court of the United States in which such bridge or any part thereof is located, for the recovery of the cost thereof." It is deemed now that the "reasonable time" mentioned in the act has elapsed, and that the provisions of the act should therefore be carried into effect without further delay.

Very respectfully, your obedient servant,

J. C. DUANE,
Brig. Gen., Chief of Engineers.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.

SAND-BAR AGAINST THE PIERS OF THE VICKSBURG, SHREVEPORT AND PACIFIC RAILWAY BRIDGE ACROSS RED RIVER AT SHREVEPORT, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., February 17, 1887.

SIR: I have the honor to make report in compliance with instructions contained in a letter from your office, dated January 13, 1887, inclosing a resolution of the House of Representatives, of which the following is a copy:

[Forty-ninth Congress, second session.]

CONGRESS OF THE UNITED STATES IN THE HOUSE OF REPRESENTATIVES.

January 11, 1887.

Mr. Blanchard, from the Committee on Rivers and Harbors, submitted the following; which was agreed to:

Resolved, That the Secretary of War be requested to inform the House what steps, if any, have been taken to cause the removal of the sand-bar which has formed against the piers of the Vicksburg, Shreveport and Pacific Railway Bridge spanning the Red River at Shreveport, La., and which for more than six months has entirely prevented the passage of boats through the draw of said bridge on a river navigable 300 miles above and 500 miles below the bridge.

Resolved further, That the Secretary inform the House whether or not the Department holds that it is the duty of said railway company to remove said obstruction;

and, if so, what demand to do so has been made upon said company, when made, and their reply, and what steps, if any, have been taken to enforce the demand.

Resolved further, That the Secretary inform the House what steps the Department proposes to take to cause the removal of said obstruction.

Attest:

JOHN B. CLARK, JR.,
Clerk.

In order to show what steps have been taken by the War Department in this matter, I give herewith the report of my predecessor, Capt. Eric Bergland, Corps of Engineers, transmitted to your office June 18, 1886, with a tracing of a survey made under his direction, a copy of which accompanies this report, in compliance with instructions given by indorsement upon a letter from Hon. N. C. Blanchard, member of the House of Representatives from Louisiana, to the Secretary of War. Captain Bergland's report contains all the information that could be obtained in regard to the construction of the bridge, with reference to the laws and extracts from all the official correspondence upon the subject on the files of this office.

LETTER FROM HON. N. C. BLANCHARD TO THE SECRETARY OF WAR.

HOUSE OF REPRESENTATIVES, U. S.,
Washington D. C., June 7, 1886.

SIR: At Shreveport, La., there is a railroad bridge across the Red River, constructed and maintained by the Vicksburg, Shreveport and Pacific Railroad Company. It is a fine and costly structure.

A suitable draw was provided for the passage of steam-boats, which has served every purpose until now. But now the channel has shifted to a span of the bridge other than where the draw is, and as a consequence the boats can not, at this low stage of the river, get above the draw. I inclose you marked copies of the Shreveport Times, showing the trouble more fully than I can here describe it.

The Red River is one of the longest rivers in our country. At high water it is navigable 500 miles above where the said railroad bridge is, and the bridge is 500 miles above the mouth of the river. Many steam-boats navigate the river.

I respectfully call the matter of the change in the channel of the river at the bridge to your attention, in order that you may take steps to have the trouble obviated.

The bill or act authorizing the railroad company to bridge the stream shows, I presume, the obligations assumed by the company in respect to maintaining navigation at and through the bridge.

I would suggest that you officially call upon the company to fulfill its covenant in this regard; or, if the railroad company can not be compelled to keep open the channel through the bridge, I would then suggest that you promptly direct the United States officer in charge of Red River improvements to take immediate steps to dredge the channel through the draw.

Whatever is done should be done at once.

An early reply will be appreciated.

If you conclude to communicate with the officer in charge of Red River, I would suggest it be done by wire to save time.

N. C. BLANCHARD, M. C.,
Louisiana.

Hon. SECRETARY OF WAR.

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
June 8, 1886.

Respectfully referred to Captain Eric Bergland, Corps of Engineers, for thorough investigation and full report upon the several points within presented; to be made at the earliest date practicable.

To be returned.

JOHN G. PARKE,
Acting Chief of Engineers.

[Second indorsement.]

U. S. ENGINEER OFFICE,
Vicksburg, Miss., June 18, 1886.

Respectfully returned to the Chief of Engineers, U. S. Army, with report of this date.

ERIC BERGLAND,
Captain of Engineers.

COPIES OF MARKED PORTIONS OF SHREVEPORT TIMES INCLOSED WITH ABOVE LETTER.

[Shreveport Times, June 1, 1886.]

THE SAND-BAR.

The steamer *John G. Fletcher*, after unloading her freight near the Silver Lake landing, attempted to pass through the railroad bridge, but was compelled to back out and tie up. The sand-bar which has formed from the Bossier side above the breakwater erected by the Vicksburg, Shreveport and Pacific Railroad Company extends below the pivot pier. There is now barely 18 inches of water between the pivot and the pier nearest the Bossier bank, and steam-boats, therefore, will be unable to go through the bridge. The channel of the river has changed positions, and the greatest depth is between the second pier and the bank on the city side of the river. Unless the sand-bar is removed by the railroad company the navigation of the river to all intents and purposes will be closed until the next rise.

[Shreveport Times, June 2, 1886.]

LOW WATER IN RED RIVER—AN EXTENSIVE SAND-BAR IN FRONT OF SHREVEPORT CLOSES NAVIGATION.

By reference to the meteorological report published in the river column of the Times it will be seen that Red River is now lower than it has been in the past eleven years. Sand-bars are creeping out gradually as the river falls, and before long it will be an easy matter for a person to cross from shore to shore in many places without a skiff or boat. In front of the city yesterday soundings were made by Uriah Vincamp, foreman draw-tender, assisted by Michael Spellman, assistant draw-tender and night toll-collector on the railroad bridge. A sand-bar extends diagonally from the old ferry landing down the center of the river, and leaves a channel from the breakwater on the east side down the river varying from 5 to 15 feet. There is also a channel on the west bank from the steam-boat landing near Cross Bayou down the river which varys from 5 to 15 feet in depth. From the line of the railroad bridge up to where the bar has formed on the east bank the water in depth varies from 18 to 36 inches. The soundings taken under the west arm of the draw give a depth ranging from 7½ feet to over 16 feet; under the east arm, between the pivot pier and the Bossier side, there is a depth of water ranging from 10 to 16 feet. The west channel between the bank on the city side and the first stone pier under the line of the bridge shows a depth of from 5 to 11 feet. Up-stream from the line of the bridge to the steam-boat landing the water varies from 4 to 11 feet. Up-stream from the line of the bridge, from the center span, the depth is from 1½ to 4½ feet. Up-stream from the west arm of the draw the water is from 1½ to 5 feet. The visible bar is below the center span, and the impediment to navigation is above and not below the railroad bridge. How to remedy this and open a regular channel to accommodate steam-boats ascending and descending the river is the question. One thing is positive; the sand-bar will not wash away, and it is more than probable that in a few days the people will be enabled to walk over to Bossier without going over the bridge or crossing in a skiff. If there is a remedy to open the channel it should be applied without delay.

REPORT OF CAPTAIN ERIC BERGLAND, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., June 18, 1886.

SIR: In compliance with first indorsement, dated Office Chief of Engineers, 8th instant, referring for thorough investigation and full report letter of Hon. N. C. Blanchard to the Secretary of War, dated 7th instant, stating that the channel of Red

River at Shreveport, La., under bridge of Vicksburg, Shreveport and Pacific Railroad Company, had shifted to a span of the bridge other than where the draw is, thereby cutting off navigation above the bridge, and requesting that action be taken by the War Department to rectify this trouble, I have the honor to submit the following report:

An examination of laws passed by Congress relating to bridges across navigable streams shows that the railroad bridge across Red River at Shreveport has received no such sanction.

This office contains no record to show that the plan of the bridge was submitted to any officer of the Corps of Engineers for suggestions or report.

November 3, 1881, Major Benyaurd, then in charge of the improvement of Red River, addressed the following communication to the superintendent of the Vicksburg, Shreveport and Pacific Railroad:

"I noticed, a few days ago, an item in the papers to the effect that the officers of the road were expected at Shreveport for the purpose of fixing upon the site of the proposed bridge across the Red. A couple of years ago a bill was introduced into Congress authorizing the construction of the bridges at Monroe and Shreveport, but never became a law. I think it would be advisable before any steps be taken towards the erection of said bridge that the plans, etc., be submitted to the War Department. The Government has expended a considerable amount of money in opening up the navigation of Upper Red, and no structure will be allowed that will in any manner impair the same. I deem it better to call your attention to the matter, so as to avoid any possible trouble in the future."

In reply to this the superintendent, under date of November 10, 1881, writes as follows:

"I have the honor to acknowledge receipt of yours of the 3d instant. The subject is one to which I will give the consideration its importance demands.

"Thanking you for the suggestion, I am, very respectfully, yours,

"F. Y. DABNEY,
"*Chief Engineer and Superintendent.*"

The following copy of a communication from the Chief of Engineers to the Secretary of War was obtained in Shreveport a few days ago:

"OFFICE CHIEF OF ENGINEERS,
"U. S. ARMY,
"*September* 21, 1883.

"Respectfully returned to the honorable the Secretary of War.

"An examination of the United States statutes fails to discover any law of Congress authorizing the construction of a bridge across the Red River at Shreveport, La., and in the absence of such law the Secretary of War has no authority either to authorize or prohibit its construction, but if he is satisfied that any intended structure of that kind will seriously impair the navigation of the channels of the navigable waters of the United States, he has not failed to endeavor through the Department of Justice to prevent the erection of such structure.

"If the proposed structure, when built upon the adopted plan, will, in the opinion of parties interested, interfere [with] or obstruct navigation, it would seem to be primarily their province to apply to the State courts for injunction, and failing in this, and the facts being such as to call for the intervention of the Federal Government, it would be lawful and proper, in order to abate the nuisance, or to prevent, enjoin, and inhibit the same, for the Attorney-General to file an information in chancery before the competent court of the United States. (Opinions of the Attorneys-General U. S., vol. 6, pp. 172-187.)

"H. G. WRIGHT,
"*Chief of Engineers,*
"*Brig. and Bvt. Maj. Gen.*"

The above include all the official correspondence on the subject which I have been able to obtain.

The bridge was located in 1882 and completed in the summer of 1884. The accompanying tracings show the location of the bridge and the arrangement of the piers and draw-span.

The tracing showing the bridge and bottom lines at the crossing was copied from a similar tracing obtained from the railroad company. It would appear from the 1882 contour line that the main channel then was near the east shore, but the depth of water is not very much greater than that under the center span.

About the time of the completion of the bridge the east bank at and above the bridge showed a tendency to caving. To prevent this the railroad company put in above the bridge four pile and plank jetties, and one below. The positions of these are shown on the map. The upper one is inclined, while the others are nearly normal to

the bank and channel. The upper or inclined jetty is throughout its whole length built up to the line of high water, while the others slope from the high-water line down to about 10 feet above low water.

It is probable that these jetties—the upper one especially—have been one of the causes of the shifting of the channel to the west bank. Of course, at this stage of water the jetties have no influence on the current, but soundings made last March, when the water was at 15.20 feet on the gauge, indicate a considerable fill nearly in the positions where the bars now appear above the surface. At that stage (15.20 feet) the current would necessarily be influenced greatly by the upper jetty.

This summer has been a remarkable exception to the general rule with reference to the stage of water. Previously (at least since 1875) the reading of the gauge during May and June has varied between 17 feet and 22 feet, giving an average of about 20 feet on the gauge, while this year the gauge-reading on the 1st of May was 18 feet; during the month the river fell steadily until the end, when the reading was 5.2 feet. During June the fall has been gradual, until the minimum was reached on the 14th, the gauge then reading 1.8 feet, since which there has been a slight rise up to 3 feet. This abnormal state of affairs has impeded navigation two months earlier than usual, as at this stage of water the larger boats which navigate Lower Red River do not attempt to go above Shreveport. To the upper river one of the smallest boats is dispatched occasionally, depending upon the amount of freight to go up or come down and the state of the river. Since the closing of the channel through the west draw-span boats from below have discharged their freight at the foot of Cotton street. This point is about as convenient for delivery of city freight as if the boats landed at the wharf-boat, which is now located near the mouth of Cross Bayou.

A narrow channel still exists through the east draw-span, through which the steamer *Richmond* passed on the 13th instant (guage 1.9 feet), drawing about 2 feet of water.

The upper sand-bar is only about 6 inches above water. Its immediate removal could probably be effected by contracting the water-way by means of a floating or fixed jetty on some such line as that indicated by the broken line on the map.

Barges could be moored on the proposed line with movable plank sheeting extending to the bottom, or a low-water pile and plank jetty could be built on the proposed line. The length of jetty will be about 500 feet. It is estimated that the hire of barges for the jetty would amount to about $30 per day. Two-inch planks can be obtained at Shreveport at $13 per 1,000 superficial feet, from 6,000 to 10,000 feet of which would be required for either system. The piling would cost, say, $2 per pile driven, and at least 50 of these would be required. If a foot mat is considered necessary to prevent scour below the jetty, this would require a further expense of $150. Additional timber and labor would probably increase the total to $500, and unforeseen contingencies, such as a sudden rise or delays occasioned by other causes, may double the cost.

It is estimated that at the end of the present month the amount available for Red River will be about $1,800.

As long as there is an uncertainty as to the passage of a river and harbor bill during the present session of Congress, it would appear to be unwise to spend a large proportion of this small balance at this time, especially as the interests of navigation suffer but little, if any, inconvenience during the present low stage of water; and, should a sudden and considerable rise occur soon, the bars which now obstruct navigation may be swept away or shifted to some less objectionable position.

That unexpected and sudden floods do occur on Red River is shown by the recent phenomenal rise at Alexandria, due to heavy rains over a restricted area. On the 14th instant the gauge-reading was 3.7 feet, just before the rain-fall began. This continued until noon of the 16th, when the signal-service gauge showed that 28 inches had fallen. The river rose rapidly until 3 p. m. on the 16th, when the gauge-reading was 28.75 feet, showing a rise of 25 feet in two days, and this without affecting the river at Shreveport, about 300 miles above Alexandria.

Very respectfully, your obedient servant,

ERIC BERGLAND,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

Immediate action was taken on Captain Bergland's report, as will be seen from the copies of letters from the office of the Chief of Engineers given below:

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., July 13, 1886.

SIR: Referring to the report of your predecessor, Capt. Eric Bergland, Corps of Engineers, dated the 18th ultimo, upon a letter of the Hon. N. C. Blanchard relative

to the obstruction to the navigation of the Red River at Shreveport, La., caused by the bridge constructed across the river by the Vicksburg, Shreveport and Pacific Railroad Company, and to other papers connected with the subject on file in your office, the inclosed communication, addressed to the president of the railroad company, is transmitted with request that you have it delivered to its address, the headquarters of the company being unknown to this office.

You are authorized to peruse this letter, and, if so desired, retain a copy of it for your records.

You will please notify this office of its proper delivery.

The following copies of the indorsements on the letter of the Hon. N. C. Blanchard, showing the action of this office and of the War Department, are furnished for your information:

"OFFICE CHIEF OF ENGINEERS,
"U. S. ARMY,
"*June* 30, 1886.

"Respectfully returned to the Secretary of War with copy of report of Capt. Eric Bergland, Corps of Engineers, to which attention is invited.

"So far as known to this office the bridge in question was built without authority of United States law, although the railway company was fully informed in regard to it before its building was commenced.

"This would seem to be such a case as is contemplated by section 8 of the river and harbor act of July 5, 1884, and it is suggested that the company or persons owning, controlling, or operating the bridge be required to cause aids to the passage of the draw opening as is required by that section.

"The appropriation for Red River is so nearly exhausted that Captain Bergland thinks it would be unwise to spend a large proportion of it at this time in removing the bar in question.

"JOHN NEWTON,
"*Chief of Engineers,*
"*Brig. and Bvt. Maj. Gen.*"

"WAR DEPARTMENT, *July* 7, 1886.

"Respectfully returned to the Chief of Engineers, who will take action as suggested by him.

"By order of the Secretary of War:

"JOHN TWEEDALE,
"*Chief Clerk.*"

Very respectfully, your obedient servant,

JOHN G. PARKE,
Acting Chief of Engineers.

Capt. J. H. WILLARD,
Corps of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., July 13, 1886.

DEAR SIR: The Secretary of War, from information furnished him, having "good reason to believe" that a bridge constructed by your company across the Red River at Shreveport, La., "is an obstruction to the free navigation" of that river by reason of difficulty in passing the draw-opening or raft-span of said bridge, it is made his duty "to require the company or persons owning, controlling, or operating said bridge to cause such aids to the passage of said draw-opening or of said raft-span, or of both said draw-opening and raft-span, to be constructed, placed, and maintained, at their own cost and expense, in the form of booms, dikes, piers, or other suitable and proper structures for the guiding of said rafts, steam-boats, and other water craft safely through said opening or span, or both said opening or span, as shall be specified in his order in that behalf," etc.

See section 8 of an act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes, approved July 5, 1884. (U. S. Stat., vol. 23, chapter 229.)

In obedience to his instructions I have, therefore, to invite attention to the requirements of this act and to request a compliance with its provisions, "within a reasonable time," in order to avoid the penalties provided for therein.

It is desired that the plan proposed for carrying out the provisions of the statute be submitted to the Secretary of War at as early a day as practicable.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Acting Chief of Engineers.

The PRESIDENT OF
VICKSBURG, SHREVEPORT AND PACIFIC RAILROAD COMPANY.
(Through Capt. J. H. Willard, Corps of Engineers.)

I sent the inclosure to Frank S. Bond, then president of the railroad company, by registered mail, notifying the Department of my action July 17, 1886, and hold the receipt, dated Cincinnati, July 20, 1886. Shortly after I received a letter from the chief engineer of the company with a copy of a letter from the president of the company to him. Copies of both are given below:

CINCINNATI, *July* 28, 1886.

DEAR SIR: A communication from the Acting Chief of Engineers, sent through you to Mr. F. S. Bond, president of the Vicksburg, Shreveport and Pacific Railroad Company, concerning the bridge over Red River at Shreveport, has been referred to me.

I note in the letter of the Acting Chief of Engineers that our company is called upon to improve the channel under the bridge by building "such aids to the passage of said draw-opening or of said raft-span * * * to be constructed * * * in the form of booms, dikes, piers, or other suitable and proper structures * * *."

As the bridge is situated about half a mile below the confluence of two streams, it is unnecessary for me to say that the improvements called for, to be effective, should be planned from a thorough survey of the locality, which should extend over a considerable period of time.

The only map that I have of any value is a very detailed one (scale 40 feet per inch), showing bed and banks of river from a point below the bridge up to the junction of Cross Bayou with Red River from surveys made in 1884, a copy of which you can have if you desire it.

By reference to the profile sent under another cover you will see that the bed of the river under the bridge has changed frequently since the construction of the bridge was undertaken. These periodical soundings were taken only on the axis of the bridge and did not extend above or below to show changes in the bed at other points.

As I find it a difficult matter upon which to predicate any plan of improvements from the information in my possession, I thought that your office might possibly have data which would be of value.

I would be thankful, therefore, if you would suggest any plan to remedy the defects in the channel complained of.

In addition I would say, from what I can gather from inquiries, I am of the opinion that there was some correspondence between one of your predecessors, Major Benyaurd, and Mr. Green or F. Y. Dabney, former engineers and superintendents of the Vicksburg, Shreveport and Pacific Railroad Company, about the year 1880 or 1881. This correspondence should appear in our files, but on account of change of ownership of the road and the removal of offices, some of the records covering the period in question are missing and I can find nothing.

I am told that a plan of the bridge was submitted to Major Benyaurd, and the plan approved.

I inclose copy of Mr. F. S. Bond's letter to me.

Yours, truly,

G. B. NICHOLSON,
Chief Engineer.

J. H. WILLARD,
Captain, Corps of Engineers, U. S. A.

P. S.—I would add that last fall a scour at some of the piers was threatening to be very dangerous, but that before an engineer could be sent, shoaling had taken place, showing the changeable nature of the channel. I send a rude plat of the river made before the bridge was built.

G. B. N.

CINCINNATI, OHIO, *July* 26, 1886.

DEAR SIR: A few days since a letter addressed to the president of the Vicksburg, Shreveport and Pacific Railroad Company, from the office of the Chief of Engineers, U. S. A., was received, stating that the Secretary of War had good reason to be-

lieve that a bridge constructed by that company across the Red River at Shreveport, La., is an obstruction to the free navigation of that river by reason of the difficulty of passing the draw-opening, and a copy was at once furnished you by my secretary.

I have this day written to the Department that the matter shall at once be attended to. Will you have the goodness to make the necessary examination and report to me what, if anything, should be done in the matter? Please make your report so full that a copy can be transmitted to the Office of the Chief of Engineers when I make my my formal report to the Department, and oblige,

Yours, very truly,

FRANK S. BOND,
President.

G. B. NICHOLSON, Esq.,
Chief Engineer, Cincinnati, Ohio.

I declined to enter into correspondence. The subject was not a proper one for me to discuss, being entirely between the War Department and the railroad company. It would have been equally improper for me to furnish or suggest a plan to remove the obstruction, unless officially directed to do so, and information and copies of correspondence bearing on the case could not be furnished from the official files of this office except upon the order of the Secretary of War.

In obedience to instructions from the Office of the Chief of Engineers, dated August 12, 1886, I submitted a project for the expenditure of the appropriation for improving Red River, Louisiana and Arkansas, made by the act approved August 5, 1886, in which I recommended, in substance, that nothing be done for the correction of the channel-way at Shreveport until it was known what the railroad company intended to do. My project was approved August 28, 1886, and work has been prosecuted in accordance with its terms, as stated in the monthly reports.

A little work has been done at the bridge for the immediate benefit of navigation. The snag-boat *Florence* experimented somewhat in washing the bar September 21, 1886, took soundings above and below the draw, gauge reading —0.3 foot, and found no difficulty in passing. The snag-boat *Howell* removed two wrecks from the east opening October 23, 1886, gauge reading + 6.1 feet. The *Florence* removed jams and wreck from the draw openings November 27, gauge reading +9.8 feet.

In obedience to General Orders, No. 7, Headquarters Corps of Engineers, November 30, 1886, calling for reports to enable the Secretary of War to comply with section 4 of the act approved August 5, 1886, I made a report December 22, 1886, in which, recapitulating the action taken by the War Department, I gave all the information on the subject available at that time. The following is an extract from the report in relation to the Shreveport Bridge:

If anything has been done by the company to improve the obstructed channel, I have not heard of it. The east channel is sufficient for present needs, and no complaints have been received at this office from any person interested in the navigation of Red River.

The statement made in the Shreveport Times June 2, 1886, that the river was lower then than at any time within the past eleven years, does not agree with the records of this office. The river then stood at +4.8 feet on the gauge, and had frequently fallen to near the low water of 1879. For the two years just preceding, however, Red River remained high during the great part of the year, but from June 1 to October 15, 1886, it was below +5.0 feet. Since October 5, with the exception of about three weeks in January, the river has been navigable through the draw at Shreveport, but the passage is exceedingly difficult, and from the direction of the current very dangerous to down-stream boats, so

that it is safe to say that navigation through the draw openings is now impracticable at any stage less than 5 feet above low water.

I give below a partial list of steam-boats that have passed the Shreveport Bridge, up or down, between September 21, 1886, and February 9, 1887:

Date.	Boat.	Approximate draught.		Gauge.
		Feet.	*Inches.*	*Feet.*
1886.				
Sept. 21	Snag-boat Florence	2	5	− 0.8
Oct. 22	Phil. E. Chappell	2	0	+ 6.0
23	Snag-boat Howell	2	9	+ 6.1
23	......do	2	9	+ 6.1
25	......do	3	0	+ 6.5
25	Snag-boat Florence	2	5	+ 6.5
27	......do	2	5	+ 6.5
Nov. 11	G. W. Sentell	3	5	+ 6.7
13	Snag-boat Florence	2	5	+ 6.5
15	......do	2	5	+ 6.4
27	......do	2	5	+ 9.8
27	Peninah	2	0	+ 9.6
30	Keokuk	3	0	+10.4
Dec. 1	Snag-boat Florence	2	5	+10.5
3	Laura Lee	4	0	+10.5
7	Yazoo Valley	3	5	+10.1
11	Peninah	2	5	+ 9.3
13	Keokuk	2	5	+ 9.0
16	Danube	2	5	+ 8.2
1887.				
Feb. 9	......do	2	5	+ 4.9

The following table gives the stage of water on the Shreveport Gauge from June 1, 1886, to February 15, 1887. The zero is low water of 1879:

Day of month.	June.	July.	August.	September.	October.	November.	December.	January, 1887.	February, 1887.
1	+4.8	+3.5	−0.1	+0.8	+2.9	+ 7.1	+10.5	+4.2	+5.1
2	+4.4	+3.3	−0.2	+0.5	+3.9	+ 7.4	+10.5	+4.2	+5.1
3	+3.9	+3.1	−0.2	+0.3	+4.4	+ 7.5	+10.5	+4.0	+5.0
4	+3.5	+2.8	−0.3	+0.1	+4.5	+ 7.6	+10.5	+3.8	+5.0
5	+3.2	+2.5	−0.4	−0.1	+4.6	+ 7.7	+10.5	+3.8	+4.8
6	....	+2.3	−0.4	−0.3	+4.8	+ 7.5	+10.4	+3.6	+4.7
7	+2.7	+2.1	−0.5	−0.5	+4.7	+ 7.4	+10.1	+3.6	+4.7
8	+2.5	+2.0	−0.5	−0.6	+4.6	+ 7.4	+ 9.8	+3.4	+4.6
9	+2.4	+1.8	−0.6	−0.7	+4.5	+ 7.1	+ 9.6	+3.3	+4.9
10	+2.4	+1.7	−0.7	−0.8	+4.5	+ 6.9	+ 9.5	+3.1	+5.3
11	+2.3	+1.6	−0.8	−0.9	+4.5	+ 6.7	+ 9.3	+3.0	+5.6
12	+2.1	+1.6	−0.8	−1.0	+4.4	+ 6.6	+ 9.1	+2.8	+0.5
13	+1.9	+1.4	−0.5	−0.7	+4.5	+ 6.5	+ 9.0	+2.6	+7.2
14	+1.8	+1.3	+1.5	−0.6	+4.9	+ 6.4	+ 8.7	+2.6	+7.8
15	+1.9	+1.1	+2.3	−0.5	+5.0	+ 6.4	+ 8.4	+2.5	+8.5
16	+2.1	+1.0	+3.0	−0.5	+5.1	+ 6.6	+ 8.2	+2.5	....
17	+2.4	+0.8	+3.2	−0.5	+5.1	+ 7.0	+ 7.7	+2.3	....
18	+2.7	+0.6	+3.3	−0.5	+5.2	+ 7.4	+ 7.4	+2.3	....
19	+3.0	+0.4	+3.2	−0.4	+5.4	+ 7.4	+ 7.0	+2.2	....
20	+3.3	+0.4	+3.0	−0.3	+5.6	+ 7.4	+ 6.7	+2.0	....
21	+3.6	+0.3	+2.8	−0.3	+5.8	+ 7.6	+ 6.3	+1.9	....
22	+3.8	+0.3	+2.5	−0.3	+6.0	+ 8.4	+ 5.9	+1.8	....
23	+3.7	+0.4	+2.3	−0.3	+6.1	+ 8.8	+ 5.5	+1.8	....
24	+3.6	+0.4	+2.0	−0.4	+6.3	+ 9.3	+ 5.2	+2.1	....
25	+3.6	+0.3	+2.0	−0.4	+6.5	+ 9.5	+ 5.0	+2.1	....
26	+3.6	+0.3	+2.0	0.0	+6.6	+ 9.6	+ 4.6	+2.4	....
27	+3.6	+0.3	+1.8	+0.2	+6.5	+ 9.8	+ 4.2	+3.0	....
28	+3.6	+0.2	+1.5	+0.4	+6.4	+10.0	+ 4.0	+3.6	....
29	+3.7	+0.2	+1.2	+0.5	+6.3	+10.3	+ 4.0	+4.7	....
30	+3.6	0.0	+1.1	+1.4	+6.3	+10.4	+ 4.0	+5.1	....
31	....	0.0	+1.0	....	+6.7	....	+ 4.0	+5.1	....

I also transmit herewith a tracing of a survey made in Januar to compare with that sent with Captain Bergland's report, and a showing the elevation of the bridge, the line of low water, and tions of the bottom at different dates. It will be noticed that t was very nearly at the same low stage when each survey was m ing slightly in June and nearly at a stand in January. The m not reduced either to the same stage or to low water, both beca desired to show the actual condition of affairs when the surve made, and because the arbitrary reduction of the water-surfac alluvial stream to low water does not give a map with contour li responding to low water, but shows a formation of the river-b can not exist at that stage.

Very respectfully, your obedient servant,

J. H. WILLARD,
Captain of Engi

The CHIEF OF ENGINEERS, U. S. A.

LETTER OF THE PRESIDENT OF THE VICKSBURG, SHREVEPOR PACIFIC RAILROAD COMPANY.

PRESIDENT'S OFFICE,
Cincinnati, Ohio, July 26, 1

DEAR SIR: Your letter of the 13th instant, addressed to the dent of the Vicksburg, Shreveport and Pacific Railroad Company the office of the Chief of Engineers, U. S. A., stating that the Sec of War has good reason to believe that a bridge constructed b company across the Red River at Shreveport, La., is an obstruct the free navigation of that river by reason of the difficulty in p the draw opening, etc., was received during my absence in the Ea have, however, instructed our chief engineer to examine into the ter at once, and make a report to me in full, which will in due cou transmitted to you when received.

Yours, very respectfully,

FRANK S. BOND,
Presid

The CHIEF OF ENGINEERS, U. S. A.

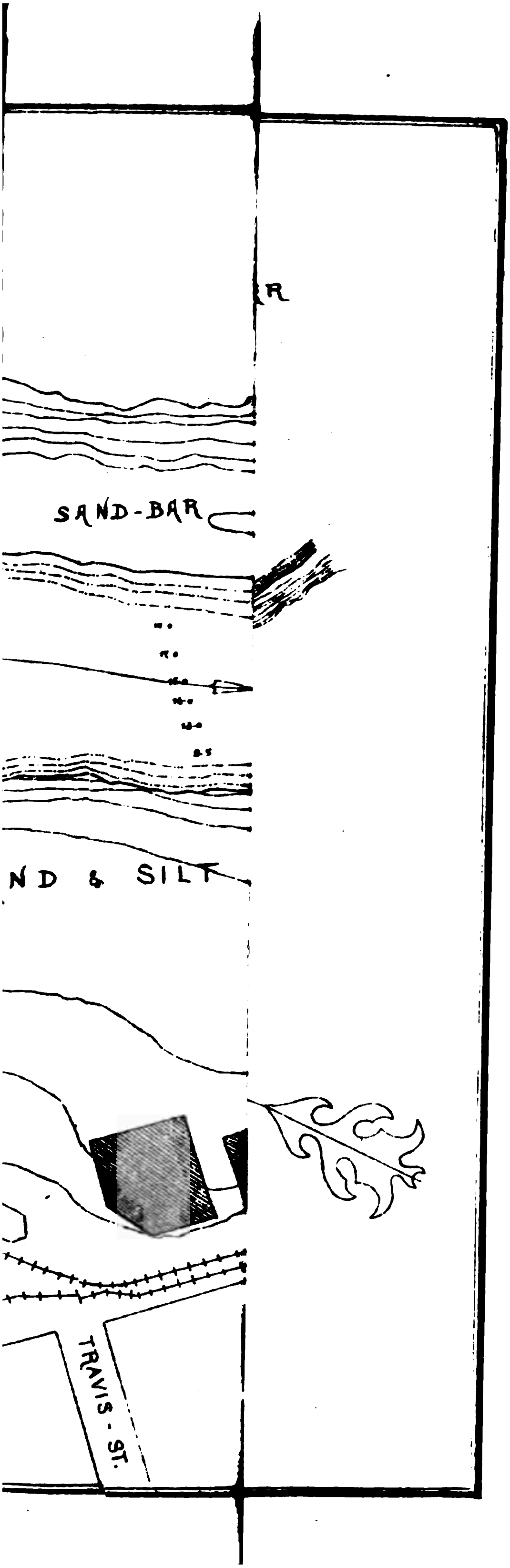
XX 7.

BRIDGE ACROSS THE WILLAMETTE RIVER AT SALEM, OREGON

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., April 18, 18

SIR: With the sanction of the War Department, a Board of Engi was constituted by Special Orders No. 183, from this office, dated vember 30, 1886, to consider and report upon the plans of the br authorized by an act of Congress, approved July 29, 1886, to be structed by the city of Salem across the Willamette River, in the S of Oregon. The Board has presented its report, herewith submi from which it will be seen that the bridge is already constructed, with certain proposed modifications there will be no serious objec to its being approved. The modifications proposed by the Board briefly stated as follows:

The river should be kept open for navigation at all stages of w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o far at least as the Salem bridge is concerned, and "this is provided or in the plan of the bridge by a channel-way around its west approach, nt the Board did not find the existence of such a channel-way to be a act." This channel-way should be "made and maintained with a least lear width of 100 feet, and on a line to be selected by the United States ngineer officer in charge of the river improvement; and an opening hrough the bridge approach of a clear width of not less than 70 feet on due east and west line should be required to be made whenever the river ses to a 25-feet stage, and to be maintained until the river falls below hat stage." This channel-way and opening in the bridge approach to be made and maintained by the owners of the bridge at their own xpense."

The views of the Board are concurred in by this office, and it is recmmended that the bridge authorities be requested to comply with its equirements, and to this end that a copy of the report of the Board be rnished for their information.

Very respectfully, your obedient servant,

J. C. DUANE,
Brig. Gen., Chief of Engineers.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.

[First indorsement.]

WAR DEPARTMENT, *April* 23, 1887.

The recommendation of the Chief of Engineers is approved, and the bridge authorities will be notified that, as they have proceeded to build the bridge without waiting for the approval of its plans by the Secretary of War, contrary to the provisions of section 3 of the act approved July 29, 1886, which provides that until the plans and location of the bridge are approved by the Secretary of War the bridge shall not be built, the Secretary of War can not approve the plans until the requirements of the Board of Engineers are complied with, and that if they are not complied with it will be necessary for him to take action under section 8 of the river and harbor act approved July 5, 1884, which prescribes the action to be taken in cases of this character.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

REPORT OF BOARD OF ENGINEERS.

PORTLAND, OREGON, *April* 3, 1887.

SIR: The board of officers of the Corps of Engineers, constituted by Special Orders No. 183, dated Headquarters Corps of Engineers, U. S. Army, Washington, D. C., November 30, 1886, "* * * to consider and report upon the plans for the construction of the bridge across the Willamette River, in the State of Oregon, authorized by the act approved July 29, 1886," has the honor to submit the following report:

By paragraph 3, Special Orders No. 13, dated Headquarters Corps of Engineers, U. S. Army, Washington, D. C., January 21, 1887, Capt. Charles F. Powell, Corps of Engineers, was relieved from duty as a member of the Board, and Lieut. Edward Burr, Corps of Engineers, was detailed as a member.

The Board met in Portland, Oregon, February 11, 1887, upon the call of the senior member; and, after considering the papers and maps re-

ferred to the Board by the Department, proceeded, on February 12, to Salem, Oregon. The Board visited the site of the bridge, and found the bridge already completed in accordance with the plans submitted to the Secretary of War for his approval. An examination was made of the bridge and its approaches and of the supposed high-water channel around the west approach.

The essential provisions of the act authorizing the bridge, as far as the purposes of this report are concerned, are:

That the bridge may be built, at the option of the city of Salem, as a draw-bridge, or with unbroken and continuous spans.

That if built as the latter, the main span shall be over the main channel of the river; shall be of such width and of such height above extreme high-water mark as the Secretary of War may prescribe; and the bridge shall be at right angles to, and its piers parallel with, the current or channel.

That the bridge shall be built and located under and subject to such regulations for the security of navigation of navigable rivers as the Secretary of War shall prescribe; and to secure that object, the city of Salem shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge and a map of the location, giving certain detailed information as to the river.

That until the plans and location of the bridge are approved by the Secretary of War the bridge shall not be built; and that any change in the plans of the bridge shall be subject to the approval of the Secretary of War.

That such alterations or changes as the Secretary of War or Congress may require in the bridge shall be made by the city of Salem at its own expense.

A copy of this act is hereunto appended.*

The Board found the bridge already completed by the city of Salem, and open to traffic as a free highway bridge. Mr. J. H. Albert, chairman of the bridge committee of the council of the city of Salem, in a letter to the Board, a copy of which is hereunto appended,* explains the circumstances of the building of the bridge previous to the approval by the Secretary of War of its plan and location.

The facts appear to be that an act authorizing a bridge had been introduced in Congress, but the committee having the matter in charge, having come to the conclusion that authority from the United States was not necessary for the building of the bridge, requested the withdrawal of this act, and proceeded to build under authority from the State of Oregon. A contract for the building of the bridge was entered into and work had commenced before the passage of the act by Congress. Rather than stop work, which would render the city liable to damages and delay work for another season, the committee proceeded with the construction of the bridge, trusting to its subsequent approval by the Secretary of War.

The bridge is constructed in accordance with the plans submitted, and has three continuous spans of combination wood and iron trusses. The piers and abutments are of iron cylinders, filled with concrete, and resting on pile foundations. The approaches are timber trestles. The whole roadway is on a grade, excepting on the center span. The spans have widths of 270 feet, 230 feet, and 200 feet, respectively, commencing at the east bank. The center span has a clear headway of 66 feet at low water. The bank at the east abutment has a timber and plank revetment. The bridge is in general at right angles to the river currents,

* Omitted.

and the piers are, as nearly as practicable, parallel to these currents, and are provided with braced and planked pile-drift breakers.

The Willamette River at Salem has on the east a bluff bank resting on cemented gravel, and on the west the low alluvial bank of the bottom-lands. Those bottom-lands have more or less of dense timber on them. The channel crosses the river just above the town, due to the bend immediately above, and follows the east bank. It may be considered permanent. Widths at ordinary low water are from 700 feet to 900 feet.

The Willamette River stands below a 10-foot stage about five-sixths of the year. Its freshets occur during the fall and winter seasons, are caused by rains, and are usually of short duration. The river both rises and falls rapidly, having been known to rise 9 feet in nine hours at Salem. The duration of high-water stages is seldom more than a few days at a time. The highest waters at Salem for each year since 1874, with the exception of 1884, have been as follows:

Years.	Height.	Years.	Height.	Years.	Height.	Years.	Height.
	Feet.		*Feet.*		*Feet.*		*Feet.*
1874	15	1877	25	1880	22.6	1883	25
1875	23.8	1878	19.5	1881	36.2	1885	28
1876	22.2	1879	22.5	1882	23.2	1886	25.4

The mean is 24.0+ feet; or, omitting high water of 1881, which was a great flood, is 22.9+ feet; and 28 feet is the limit of ordinary high water.

The following table gives the duration of the different stages of the river at Salem for the years 1879, 1880, and 1881, the only years for which readings are available; 1881 was the year of highest water. It shows the short duration of stages above 20 feet, and especially of stages above 23 feet.

WILLAMETTE RIVER AT SALEM.

Table showing duration of river stages for the years 1879–'81.

Gauge-readings.	1879.	1880.	1881.	Gauge-readings.	1879.	1880.	1881.
	Days.	*Days.*	*Days.*		*Days.*	*Days.*	*Days.*
0 to 1 foot	64	64	....	20 feet to 21 feet	3	1	....
1 foot to 2 feet	41	40	61	21 feet to 22 feet	....	2	2
2 feet to 3 feet	28	24	61	22 feet to 23 feet	3	1	3
3 feet to 4 feet	37	34	25	23 feet to 24 feet	....	....	....
4 feet to 5 feet	24	19	46	24 feet to 25 feet	....	....	1
5 feet to 10 feet	87	140	109	25 feet to 30 feet	....	....	5
10 feet to 15 feet	55	34	29	30 feet to 35 feet	....	....	3
15 feet to 20 feet	23	7	18	35 feet to 40 feet	....	....	2

Navigation is suspended to a large extent at low-water stages. At flood stages the river currents are very strong in places, and the river carries a great deal of drift. The locks at Oregon City, 70 miles below Salem, formerly largely controlled the navigation of the Upper Willamette River, and still do so in a lesser degree. These locks are closed by a stage of 11.5 feet at Oregon City; and this suspends all navigation on the river from above to Portland. But the river itself is navigable at all flood stages. To obtain information on this point, a letter (copies of letter and replies hereunto appended*) was addressed to masters of steam-boats on the Upper Willamette River, and they were unanimous on this point.

* Omitted.

New lines of railroad, connecting with the river traffic at points above Oregon City, have materially changed the condition of affairs that formerly existed, and navigation of the Upper Willamette River will, and does, continue after the Oregon City Locks are closed by high water. The river, then, should not be obstructed to navigation at any stage, and the Oregon City Locks must be neglected in considering the question.

With the bridge under consideration, the only question is as to whether it gives a sufficient headway for the passage of boats at high-water stages. The location is good, and perhaps as little objectionable as any that could have been chosen.

The bridge is practically at right angles to, and the piers are practically parallel with, the currents, and the passage of boats is easy. The spans are ample, and the piers form but slight obstructions.

The clear headway at low water is 66 feet. At a 25-foot stage boats drawing 3 feet can pass around the west end of the bridge if provision be made for this passage by clearing a proper channel-way through the timber above and below the bridge, and by making removable a portion of the bridge approach, which consists of pile bents, stringers, and flooring, and which slowly grades down to the level of the bottom on the west bank.

There will be a clear headway of $66-25=41$ feet under this bridge at a 25-foot stage; and above that stage there will be a clear passage-way around the bridge of a depth of 3 feet or more, and navigation will always be possible to boats of a not greater height than 41 feet. To stages of 28 feet, the limit of ordinary high water, boats of a not greater height than 38 feet will always have sufficient headway under the bridge. Floods of more than 28 feet are of very infrequent occurrence, there being but one recorded greater. The following table shows the heights above the water-line of the smoke-stacks, king-posts, and pilot-houses of Upper Willamette River steamboats:

Height above the water-line of the stacks, king-posts, and pilot-houses of Willamette River steamboats.

Name.	Stack.		King-post.		Pilot-house.	
	Feet.	*In.*	*Feet.*	*In.*	*Feet.*	*In.*
City of Salem	48	1	41	3	30	11
Salem	44	2	40	3	28	0
Bonanza	50	9	37	7	33	4
Willamette Chief	57	4	55	10	33	11
S. F. Church	52	7	52	1	32	0
Champion	46	2	36	3	29	1
A. A. McCully	42	0	41	4	33	2
Orient	49	10	44	8	30	11
Occident	....		42	11	33	0

The greatest heights of smoke-stack, king-post, and pilot-house are, respectively, 57 feet 4 inches, 55 feet 10 inches, and 33 feet 11 inches. This height of pilot-house proves ample, and navigation interests on the Upper Willamette River will not, probably, call for larger boats, or higher pilot-houses in the future. Smoke-stacks can readily be jointed and let down below the pilot-houses. As to the king-posts, Major Jones, in his report on this bridge, says:

These high hog poles are peculiar to this locality. I have made a careful examination of the subject and consulted with the best builders of boats and am satisfied that such heights are wholly unnecessary. For sums less than a hundred dollars they can be replaced with queen-posts or cut down flush with the pilot-houses.

The Board is also of the opinion that these king posts are unnecessarily high, that they can be cut down at a small expense, and that the height of the pilot-houses of steamboats should govern the headway under bridges on this river, as it does on the Mississippi and Ohio. A headway of 41 feet under this bridge, at the stage that will open a channel around the bridge, seems to the Board sufficient, in view of the facts that the greatest height of pilot-house is but 33 feet 11 inches; that this pilot-house is that of a boat not properly an Upper Willamette River boat; that the heights of the pilot-houses of the two largest carriers, *Bonanza* and *Champion*, are respectively 33 feet 4 inches, and 29 feet 1 inch, and that the probabilities are against any future increase in size of the boats of this river.

The short duration of the high-water stages would cause this bridge to be an obstruction to navigation for only short periods, and at long intervals apart, even if a channel-way around the end of the bridge were not provided. In 1881, the year of greatest flood, the river was above 23 feet but eleven days, and for not more than six days at any one time; and in 1879 and 1880, did not rise above 23 feet. But, as the river is navigable and navigated at all high stages, and as at high stages property and life are endangered and may be saved by the prompt arrival of a steam-boat, the Board deems it advisable, so far at least as the Salem Bridge is concerned, to keep the river open at all stages.

This is provided for in the plan of the bridge, by a channel-way around its west approach; but the Board did not find the existence of such a channel-way to be a fact.

Such a channel-way should, then, be required to be made and maintained, with a least clear width of 100 feet, and on a line to be selected by the United States engineer officer in charge of the river improvement; and an opening through the bridge approach of a clear width of not less than 70 feet on a due east and west line, should be required to be made whenever the river rises to a 25-foot stage, and to be maintained until the river falls below that stage. This channel-way and opening in the bridge approach should be made and maintained by the owners of the bridge at their own expense.

It may be remarked here that, during the time that this temporary opening would be required in the approach, the bridge is closed to traffic by the flooding of the end of this approach.

The Board therefore recommends that such a channel-way be made, and that the bridge approach be prepared for making such a temporary high-water opening through it. When these improvements have been made and proper guaranties have been given that they will be maintained, the Board sees no serious objection to the approval of the bridge as constructed.

The papers referred to the Board are returned herewith.

Very respectfully, your obedient servants,

W. A. JONES,
Major of Engineers.
W. YOUNG,
Captain of Engineers.
EDW. BURR,
First Lieutenant of Engineers.

To the CHIEF OF ENGINEERS, U. S. A.

APPENDIX Y Y.

REPORTS OF THE MISSISSIPPI RIVER COMMISSION.

Y Y 1.

REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR 1886.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, September 20, 1886.

SIR: The Mississippi River Commission has the honor to submit the following report, embracing the subjects specified below, to wit:

(1) Progress of surveys and examinations from July 1, 1885, to June 30, 1886.
(2) Progress of construction from July 1, 1885, to June 30, 1886.
(3) Levees.
(4) Financial statements and estimates.

PROGRESS OF SURVEYS AND EXAMINATIONS.

No field work has been done. A small force was retained till the close of the fiscal year, in the office, under the direction of the Secretary of the Commission, for the reduction of the work of previous seasons.

Gauges.—In September, 1885, for want of funds, the gauge readings

at Grand Eddy, Mo.; Paducah, Ky.; Belmont, Mo.; Greenville, Miss., and College Point, La., were discontinued. There remain eighteen stations at which gauges are maintained.

Discharge observations.—The reduction of the notes of the six discharge parties which were in the field from September, 1884, to April, 1885, has been continued and will soon be completed.

Preparation of maps.—Work on the charts of the 1 : 10,000 series, 233 in number, is approaching completion; and the 1 : 20,000 series, reduced from the preceding, is in process of publication. The inch-to-the-mile series has been published complete, but some of the sheets require additions from later surveys. The map of the Alluvial Valley, on a scale of 1 inch to 5 miles, is finished, and ready for printing when funds are available.

(For details see report of Captain Turtle, Appendix A.)

PROGRESS OF CONSTRUCTION.

In the absence of appropriations no work has been done in the districts below Cairo, beyond what was necessary for care and preservation of property, except such moderate repairs of existing works as could be made with the balances available for contingencies.

The general service purchased and delivered stone for repairs of revetment at Hopefield Bend, in November and December, 1885, and part of its plant is now employed in the work for the protection of the Memphis City front.

(For details see the report of Captain Turtle, Appendix B.)

The present value of the construction plant owned by the Government, and employed on the Mississippi River from Des Moines Rapids to the Head of the Passes, is, approximately, $1,061,000, of which $1,014,000 is in floating plant, and $47,000 in instruments, office furniture, tools, &c. Detailed statements of this plant and of its value are given in the reports of the several officers. Two tow-boats belonging to the third district have been lent to the Missouri River Commission during the suspension of operations.

The diminution in value since the last report, amounting to about $200,000, in part represents the deterioration during a long period of disuse. In the Illinois-Ohio River district, in February, 1886, a loss of $40,000 was occasioned by floating ice. On the other hand, a constant expenditure has been required to secure the idle plant from decay and total loss.

In November, 1885, a tour of inspection from Keokuk to New Orleans was made by the Commission, and a supplemental report, containing the information then obtained as to the condition of the works and their effect, was submitted December 18, 1885.

(See Ex. Doc. No. 38, H. of R., 49th Congress, 1st session.)

WORKS ABOVE CAIRO.

(District from Des Moines Rapids to Illinois River, 161 miles. Officer in charge, Capt. E. H. Ruffner, Corps of Engineers.)

The general plan in this district contemplates closing side channels by low dams, revetting banks subject to erosion, and regularizing the channel, with the view of providing a navigable depth of 5 feet at low water. Dredging is employed to aid the action of the dams or to remove temporary obstructions, the material excavated being used for foundations of brush dams when suitable.

The operations of the past year comprise repairs to closing dams at Denmark, Carroll, Hickory, and Slim islands, construction of dams at Westport Chute and the Fritz islands, completing revetment at Cincinnati Landing, and dredging in Quincy Bay, Hickory Chute, and on Wyaconda Bar, with minor repairs and work of shore protection.

Navigation during the year has been generally good, but little detention from shoal water being reported.

(For details see report of Captain Ruffner, Appendix C.)

(District from the Illinois River to the Ohio River, 241 miles. Officer in charge, Maj. O. H. Ernst, Corps of Engineers.)

The general plan in this district contemplates a continuous improvement from Saint Louis down, by confining the river to an approximately uniform width of 2,500 feet and protecting the banks from erosion. The object is to secure a minimum low-water depth of 6 feet from the mouth of the Illinois to Saint Louis, and of 8 feet from Saint Louis to the Ohio. The methods employed are to direct the flow, and to build up new banks with solid material caught from the river itself by means of hurdles, and to revet the new banks so formed as well as the natural banks where subject to caving. Work is also done at detached points, when specially authorized, as at Alton and Saint Louis harbors and on the east bank near Cairo.

From lack of funds operations have been confined to such repairs as were necessary to prevent loss, and to additions that seemed advisable in view of the action of existing works. Repairs were made at Horsetail, Twin Hollows, and Chesley Island, and the hurdles at Pulltight and Jim Smith's were raised.

The works in this district suffered little damage during the winter, and are now in good condition. Large deposits have been formed behind them, and a minimum channel depth of 8 feet maintained for 22 miles below Saint Louis. A least depth of 5½ feet is reported in that part of the river which has not been improved.

On February 13, 1886, the fleet of this district was carried from its winter harbor, behind Carroll's Island, 12 miles below Saint Louis, by ice, and several pieces destroyed or damaged beyond repair. The loss including expenses of recovery and repair, was about $40,000.

(For details see report of Major Ernst, Appendix D.)

WORKS BELOW CAIRO.

The general plan adopted by the Commission for the improvement of the river from the mouth of the Ohio to the mouth of Red River contemplates the reduction of the low-water width to about 3,000 feet, by means of permeable dikes, behind which artificial banks shall be formed by deposit, and the preservation of the natural curves of the river by revetting caving banks, together with the construction of levees as a secondary means of maintaining the regimen of the river. Below Red River, by reason of the depth of water and the comparative stability of the banks, no works of contraction are required.

The rectification of the Red and Atchafalaya Rivers presents a special problem, a solution of which was offered by the Commission in their report of December 19, 1884, the plan presented being, however, subject to modification after further study of the conditions.

Beyond their general plans, works of improvement and protection at certain places have been specially authorized and placed in charge of the Commission.

FIRST DISTRICT.

(Cairo to foot of Island No. 40, 220 miles. Includes New Madrid and Plum Point Reaches. Officer in charge, Capt. Smith S. Leach, Corps of Engineers.)

Since the last report no work has been done in this district beyond what was necessary for the care and preservation of plant, and such slight repairs to the works on Plum Point Reach as their condition seemed to require and the state of the funds permitted. A small break at the upper angle of the Osceola-Bullerton Dike was closed, with the immediate effect of filling up the excavation behind it, which had been caused by the scour of the current through the gap.

The damage to the works during the past year has been slight, and has not materially impaired their efficiency. A considerable amount of pile-dike hás been broken off at the 20-foot level from the decay of the material used, but the lower parts, with the foot-mats, remain, and the deposits which have formed behind them are unaffected. The revetment at Fletcher's Field was exposed at both ends by the caving of the unprotected bank above and below it, but has held its place with very little loss.*

The main low-water channel through this reach is becoming well defined, both in position and in depth, while the secondary channels are being obliterated. The channel through Plum Point Crossing has not changed its form during the past season, through all stages of the river.

(For details of the work and tabulated results of surveys see report of Captain Leach, Appendix E.)

SECOND DISTRICT.

(Foot of Island No. 40 to mouth of White River. Includes Memphis Reach and Harbor. Officer in charge, Capt. Smith S. Leach, Corps of Engineers.)

The only works of improvement in this district during the past year have been the repair of a serious fault in the revetment of Hopefield Bend and the reballasting of a part of this revetment, and of that on the Memphis city front. This was completed in January, 1886, since which time no change has taken place in the condition of the work at either place. The amount expended was about $20,000.

The effect of maintaining the bank in Hopefield Bend has been to cause the river to cut away the bar which was forming on the point below, and to transfer the stress of the current on the left bank to the southern part of the city front. The caving along this tract threatening serious loss, a sum of $60,000 has been subscribed by citizens and railway companies interested, and, by authority of the Secretary of War, plant has been furnished, to be used under direction of the Engineer officer of the district, in securing this front by a system of crib-spurs, such as have been successfully tried at New Orleans.

(For details see report of Captain Leach, Appendix F.)

THIRD DISTRICT.

(Mouth of White River to Warrenton, Miss., 220 miles. Includes Lake Providence Reach and Vicksburg and Greenville Harbors. Officer in charge, Capt. William T. Rossell, Corps of Engineers.)

(1) *Lake Providence Reach.*—The only work of improvement during the past year has been the closing of gaps in the Baleshed and Stack

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*Recent examination shows that the Craighead Point revetment, which was supposed to have disappeared, is still in place and entire.

Island system of dikes, by repairs and extension of existing works, and construction of one additional cross-dike, the whole amount expended being about $13,000.

Examination shows in general satisfactory results from the works. Even where the dikes have disappeared, as at Duncansby, they had already accomplished the purpose for which they were built, and the channel secured by them is still maintained. The revetment at Pilcher's Point has, in many places, slipped out of sight, but the bank line has substantially retained its position. The Mayersville revetment has not succeeded in holding the head of the island.

The least channel depth on the reach during the year has been 13 feet.

(2) *Vicksburg Harbor.*—No work has been done here during the year. Examination shows that the cut through the bar, which was dredged in 1883 to the zero of the gauge, has been filled to an average depth of 7.5 feet. The revetment at Delta Point has suffered no material loss, and the shore-line is unchanged.

(For details see report of Captain Rossell, Appendix G.)

FOURTH DISTRICT.

(Warrenton, Miss., to Head of Passes, 484 miles. Includes Harbors of Natchez and Vidalia and New Orleans, mouth of Red River, and rectification of Red and Atchafalaya Rivers. Officer in charge, Maj. Charles W. Raymond, Corps of Engineers.)

The work in this district has been confined to the mouth of Red River, where the channel was kept open during the low-water season of 1885 by scraping and by temporary wing-dams, at a cost of $11,000.

Examination of the spurs in process of construction in Gouldsboro' Bend, New Orleans Harbor, shows that since they were begun the 100-foot contour has moved outward, and the other contours have become more regular. Their full effect, however, cannot be ascertained until the system is completely developed.

(For details see report of Major Raymond, Appendix H.)

LEVEES.

No new levee work has been done during the year. From February to May, 1886, about $3,500 was expended in the fourth district in repairs to the sinking portion of Kempe Levee, at Potter's Slough.

Numerous small breaks, due to insufficient height, occurred in the third district levees, between Cypress Creek and Arkansas City, during the flood of 1886. Breaks are also said to have taken place in the Long Lake Levee, second district. Elsewhere the Government levees have remained intact.

The condition of levees along the entire alluvial valley is, briefly, as follows:

Saint Francis Front.—(1) From Commerce to Bird's Point, 38 miles, which is the head of the flood escape into the Saint Francis Basin, there are no levees, and no estimates have been made for closure.

(2) In the first district, Cairo to foot of Island 40, 220 miles, the levees have been neglected since their destruction in 1858; not more than 1 per cent. of the old system could be utilized in the construction of a new line. The estimate for a complete line is 8,910,000 cubic yards, at a cost of $2,300,000.

(3) In the second district, foot of Island 40 to the Saint Francis River, 78 miles, about one-third of which is unleveed, it is estimated

that to complete the line and raise all levees to 1½ feet above high water of 1882 will require 1,634,000 cubic yards, at a cost of about $430,000.

White River Front.—Saint Francis River to White River, 95 miles. Less than 20 miles of this front is unleveed, but much of the remainder has too low grades. It is estimated that the entire front can be closed to 2 feet above high water for about $150,000. The Long Lake Levee is the only Government work.

From White River to Arkansas River there are no levees.

From Arkansas River to Cypress Bayou, 25 miles, there are no front levees except a few miles more or less dilapidated. The south side of the Arkansas is leveed for about 8 miles above the mouth.

Tensas Front.—Cypress Creek to Red River, 340 miles. On the south side of Cypress Creek, the Opossum Fork Levee extends back from the river and across to Amos Ridge, 7 miles, closing the head of the Tensas Basin. From Amos Ridge to Arkansas City, for new levees, closing breaks, and raising grade to 1 foot above high water of 1882, there are required 133,000 cubic yards.

From Arkansas City to the Louisiana State Line there is required for enlargement of existing lines 526,000 cubic yards; for new levees, 976,000 cubic yards, the principal new work being at—

	Cubic yards.
Panther Forest	272,000
Leland	78,000
Vaucluse	179,000
Matthews Bend	173,000
Grand Lake	232,000

From the Louisiana State Line to Warrenton the levees are at present in fair condition. There are, however, caving banks, which will ultimately necessitate new levees, for which the estimated amount is 1,027,000 cubic yards. The Wilton to Raleigh Levee is the most important of those threatened.

From Warrenton to Red River the levees are believed to be above ordinary flood height, except at Diamond Island Bend (13,850 feet) and Bougère, with a small gap at Point Breeze. The estimate of the chief State engineer of Louisiana for the closure of Diamond Island Crevasse is 250,000 cubic yards, or, for a more complete line across Sargent's Point, 510,000 cubic yards. No estimates have been made for the other localities named.

In addition, it seems likely that caving will render necessary the reconstruction of Kempe Levee. (See report of Major Stickney, M. R. C. An. Rep., 1885.) The grade of Lake Concordia Levee is still too low.

On the Yazoo Front the energetic action of the State boards has kept the levees in fair condition, although much work remains to be done before that front is quite secure.

Atchafalaya Front.—The Morganza crevasse is the only point that needs special attention. The estimate for closure is 270,000 cubic yards.*

FINANCIAL STATEMENT.

Appropriation for salaries and expenses Mississippi River Commission, act of July 7, 1884.

Amount appropriated	$75,000 00
Balance on hand July 1, 1885	22,721 24
Expended from July 1, 1885, to June 30, 1886	19,182 45
Balance on hand July 1, 1886	3,538 79

* Work is in progress on this levee, and it will probably be completed during the season.

Appropriation for surveys Mississippi River, act of July 5, 1884.

Amount appropriated	$75,000 00
Balance on hand July 1, 1885	16,148 57
Expended from July 1, 1885 to June 30, 1886	14,870 26
Balance on hand July 1, 1886	1,278 31

Appropriations for improving Mississippi River, acts of March 3, 1881, August 2, 1882, and January 19 and July 5, 1884.

Balance July 1, 1885	$389,978 05
Received from sale of fuel	220 34
Total	390,198 39
Expended from July 1, 1885, to June 30, 1886	274,326 89
Balance July 1, 1886	115,871 50

Estimate of funds for the Mississippi River Commission for the fiscal year ending June 30, 1888

SUNDRY CIVIL BILL.

For salaries and traveling expenses of the Mississippi River Commission, and for salaries and traveling expenses of assistant engineers under them, and for office expenses and contingencies	$100,000

RIVER AND HARBOR BILL.

For continuation of surveys of the Mississippi River, between the Head of the Passes, near its mouth, and its headwaters, now in progress; to make additional surveys and examinations of said river and its tributaries; to make such additional examinations and investigations, topographical, hydrographical, hydrometrical, as are necessary for maturing a plan for the permanent improvement of the entire river	100,000
Estimate of funds for the improvement of the Mississippi River for the fiscal year ending June 30, 1888:	
For continuing the improvement of the Mississippi River from Cairo, Ills., to the Head of the Passes, including the improvement of the Red River at and below the head of the Atchafalaya	5,000,000
For the improvement of the following harbors:	
Columbus, Ky	$61,250
Hickman, Ky	251,250
Memphis, Tenn	25,000
Greenville, Miss	148,500
New Orleans, La	608,600
Total	$1,094,600

Q. A. GILLMORE,
Colonel of Engineers, Bvt. Maj. Gen., U. S. A.,
President Miss. River Commission.
CHAS. R. SUTER,
Major of Engineers, U. S. A.
HENRY MITCHELL,
Coast and Geodetic Survey.
B. M. HARROD.
R. S. TAYLOR.
S. W. FERGUSON.

I expressed, in the report of the Mississippi River Commission for 1883, my opinion as to the approximate heights needed for levees to give protection against overflow along the Mississippi River. I think the estimate for levees given in this report totally inadequate for any efficient system.

C. B. COMSTOCK,
Lieut. Col. of Engineers.

Hon. WM. C. ENDICOTT, *Secretary of War.*
(Through the Chief of Engineers, U. S. A.)

List of appendices accompanying the foregoing report.

APPENDICES.

APPENDIX A.

ANNUAL REPORT OF THE SECRETARY OF THE COMMISSION UPON THE WORK OF SURVEYS AND EXAMINATIONS.

OFFICE MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
Saint Louis, Mo., July 31, 1886.

GENERAL: I have the honor to submit the following report of the work of the secretary's office and of surveys and examinations during the fiscal year ending June 30, 1886.

The operations carried on under this office for the past year have been the inspection and repair of gauges on the main river below Saint Louis and on the tributaries; the checking, compilation, and publication of gauge records; the reduction and plotting of field notes, and the preparation, publication, and distribution of maps; the printing of tabulated data, gauge records, proceedings of the Commission and reports; the reduction of the notes of discharge observations, and the computations therefrom; the reduction and compilation of physical data of the Mississippi River and alluvial valley; the classification and filing of the reports and records pertaining to the Commission; the disbursement of the funds appropriated for the expenses of the Commission, and for surveys under its direction; and the clerical work rendered necessary by these duties. At the end of the fiscal year no assistants remained on the rolls of this office, the services of all having been dispensed with from time to time because of lack of funds.

PREPARATION AND PUBLICATION OF MAPS.

Of the manuscript maps, 233 in number, of the Mississippi below Cairo, covering some 945 miles of river, 14 are finished. The others are in various stages of progress; 209 require titles and notes, and 28 require conventional signs. This series is on a scale of 1 to 10,000. From this series a series on the reduced scale of 1 to 20,000 is in process of publication. There will be 69 charts, only 9 of which have been published; the material for 30 more is prepared, awaiting funds to pay for printing.

The series on a scale of one inch to the mile, and of which a complete set of 32 charts, covering the river from Cairo to the head of the passes, has been published, requires the addition of topography from later surveys upon 9 of the sheets. To carry this series up to Keokuk will require some 14 sheets, upon which no work has been done.

The map of the alluvial valley, which shows the entire overflowed region from Cape Girardeau to the Gulf of Mexico, consisting of 8 sheets, on a scale of one inch to five miles is finished, and an edition may be printed as soon as funds are available.

The black impressions are on stone, and for security against loss, transferred copies on zinc plates are prepared and stored elsewhere. The color impressions are provided for by zinc plates.

The discharge observations, made in the season of 1884-'85, at Helena, Warrenton, Red River Landing, Old River (mouth of Red River), and at the head of the Atchafalaya have been reduced and tabulated.

Very respectfully, your obedient servant,

THOMAS TURTLE,
Captain of Engineers, Secretary Mississippi River Commission.

General Q. A. GILLMORE,
President Mississippi River Commission.

FINANCIAL STATEMENT.

Appropriation for salaries and expenses Mississippi River Commission, act of July 7, 1884:

Appropriated by act of July 7, 1884	$75,000 00
Balance on hand July 1, 1885	22,721 24
Expended from July 1, 1885, to June 30, 1886	19,182 45
Balance on hand July 1, 1886	3,538 79

Appropriation for surveys of Mississippi River, act of July 5, 1884:

Amount appropriated	$75,000 00
Balance on hand July 1, 1885	16,148 57
Expended from July 1, 1885, to June 30, 1886	14,870 26
Balance on hand July 1, 1886	1,278 31

Approximate value of plant belonging to the United States and used by the Mississippi River Commission in surveys and examinations of the Mississippi River.

[Appropriation for Mississippi River Commission.]

Class of property.	Approximate value, June 30, 1886.
One steamer, "Patrol"	$14,000
Three launches, Nos. 1, 2, 3	5,000
One steam tug, "Frolic"	1,000
Six quarter boats	12,000
Skiffs, &c	700
Outfit	4,000
Tools and appliances	800
Surveying instruments	12,000
Drawing instruments	700
Office furniture	800
Printing press, &c	850
Current meters and outfit	1,900
Total	53,250

[Appropriation for Surveys of Mississippi River.]

Class of property.	Approximate value June 30, 1886.
Three launches, Nos. 4, 5, 6	$7,500
Current meters and outfit	800
Outfit	200
Tools and appliances	100
Total	8,600

THOMAS TURTLE,
Captain of Engineers, Secretary Mississippi River Commission.

Itemized statement of expenditures of "Mississippi River Commission," appropriation of July 7, 1884.

Items.	Services assistant engineers.	Services draughtsmen, rodmen, &c.	Supplies.	Subsistence.	Transportation.	Mileage and traveling expenses.	Total.
Salaries of commissioners							$8,250 00
Mileage and inspection		$5 45	$9 77	$67 20	$15 25	$1,999 05	2,096 72
Salaries and traveling expenses, assistant engineers	$3,336 67					24 50	3,361 17
Publication of maps			19 25				19 25
Office: Services, clerks, &c., $3,994.94; rent, $1,000; fuel, $132.50; supplies, $51.51; transportation, $53.01; stationery, $33.15; telegrams, $26.98; miscellaneous, $163.22							5,455 31
Total	3,336 67	5 45	29 02	67 20	15 25	2,023 55	19,182 45

SUMMARY.

Balance from appropriation of July 7, 1884	$22,721 24
Expenditures for fiscal year ending June 30, 1886	19,182 45
Balance	3,538 79

THOMAS TURTLE,
Captain of Engineers, Secretary and Disbursing Officer Mississippi River Commission.

Itemized statement of expenditures for "Surveys of Mississippi River," act of July 5, 1884.

Items.	Services assistant engineers.	Services draughtsmen, rodmen, &c.	Outfit.	Supplies.	Photographing and printing.	Repairs.	Transportation.	Traveling expenses.	Stationery.	Fuel.	Miscellaneous.	Total.
Reduction and publication	$5,857 34	$720 41	$16 00	$216 69	$401 85	$0 50	$8 65	$26 75			$4 50	$7,255 69
Field work of topography										$47 25		47 25
Inspection and maintenance of gauges	1,375 00	3,630 50	10 40	81 36		6 56	74 45	495 75	$31 25		49 70	5,754 97
Miscellaneous surveys				1 00		3 00	3 40			31 50	10 20	49 10
Care of property		1,020 00		118 50		4 75						1,143 25
Office: Services clerks, &c., $420; rent, $200												620 00
Total	7,232 34	5,370 91	26 40	417 55	404 85	14 81	86 50	522 50	31 25	78 75	64 40	14,870 26

SUMMARY.

Balance from appropriation of July 5, 1884	$16,148 57
Expenditures for fiscal year ending June 30, 1886	14,870 26
Balance	1,278 81

THOMAS TURTLE,
Captain of Engineers, Secretary and Disbursing Officer Mississippi River Commission.

A 1.

DISCHARGE OBSERVATIONS AT HAMPTON LANDING, ARK., DECEMBER 23, 1878, TO JUNE 25, 1879.

[Extracts from the report of Mr. H. B. Herr, Assistant to Maj. W. H. H. Benyaurd, Corps of Engineers, dated October 20, 1879.]

* * * * * * *

DESCRIPTION OF LOCATION.

The site selected as being most suitable for the observations, and also in the vicinity of Memphis, Tenn., as required by the order instituting the observations, was at Hampton Landing, Ark., about 12 miles by the river channel below Memphis.

Some of the considerations which led to the selection of this locality were the following, viz: a straight reach of river, high banks on both sides, a rather uniform depth of water on section across the river, a less width than elsewhere in the vicinity, and the comparatively permanent condition of the banks. Although there had been, and was during the progress of observations, much caving of the bank on Arkansas side immediately above, none was observed on either side, at the station, during the time it was occupied.

The accompanying map of location furnishes some details as to the river itself in the vicinity, and a plan of bases and cross-sections. (See Plate I.)*

OBSERVATION PARTY.

The field party was under the immediate charge of H. St. L. Coppée, C. E., with F. S. Burrowes and H. C. Wilson as Assistant Engineers. A recorder, leadsman, six oarsmen, cook, and a roustabout completed the party.

They were established at their station, with quarters on a small boat, early in December, 1878.

Owing to delay occasioned by difficulty encountered in using floats, as explained hereafter, and heavy floating ice during almost the entire month of January, but little satisfactory work was accomplished before February 1, 1879. From this date until operations were suspended, June 30, the only interruptions were those due to high winds and rain storms. Much time was lost on this account.

FLOATS.

To measure the velocity of the current the method by double floats was adopted. The first form tried was that used by Mr. T. G. Ellis on the Connecticut River, and described in his report upon the survey of that river. (See Part I of the Report of the Chief of Engineers, 1878.)

After a few trials it was found that the sub-float was not strong enough to resist the pressure of the water at a greater depth than about twenty feet. The outer cylinder would collapse, thereby reducing volume of air-chamber so greatly that the sub-float would sink to the bottom and submerge the surface-float.

To obviate this difficulty, and to secure other advantages, a modified form was constructed in which the air-chamber of sub-float was formed by placing a cylinder inside of a main one, and extending from its top to middle. A conical surface connected the bottom of inner cylinder with the main one. This main cylinder, made of heaviest tinned iron, was 12 inches long and 10 inches diameter; the inner one had a diameter of 8.7 inches. Instead of placing the lead for ballast on cross wires, as in first form, it was soldered to inside of bottom in the form of a ring.

This disposition of the lead, together with the favorable slope of bottom of air-chamber, greatly facilitated the descent of sub-float when dropped into the water, and rendered it less susceptible to the influence of ascending "whirls" and "boils," so numerous at the station occupied. The air space being concentrated about the top gave the float great stability in an upright position in the water.

For the disk-shaped surface float a cylinder 6 inches long and 4.5 in diameter, with conical ends, was substituted. The cones had altitudes of 3 and 4.5 inches, respectively, and the loop to which the cord connecting surface and sub-float was attached, was placed nearer the end having the more acute cone. This form gave greater buoyancy for the same amount of material and offered less resistance to any other than a vertical pull on the cord. This diminution of resistance permitted the sub-float to exercise a more perfect control over the movements of its surface-float. Since the velocity of sub-float is

*Not printed.

determined by locating positions of its surface-float, the importance of such control is very palpable.

Although this float resisted the water pressure much better than the first form, and was quite satisfactory for depths not exceeding about 40 feet, it also collapsed at greater depths, and, as before, submerged the surface-float.

To secure sufficient resistance to pressure at any depth it might be desirable to run floats, a third form was devised, in which, instead of one air-chamber there were sixteen, formed by soldering as many small semi-cylinders to the outside of the upper part of a main cylinder of same dimensions as the former one. The disposition of the lead was the same as before, 2 pounds being the quantity used. The greatest depth at which this float was tested was about 70 feet, but it would undoubtedly withstand the pressure at a much greater depth. It was used from February 19 until the close of field work.

The cord finally adopted for connecting surface and subfloat was a braided silk, size C. Its diameter was 0.05 inches and breaking strain about 36 pounds. Oiled silk and linen were also tried, but none appeared so durable for same thickness as the one adopted.

The volume of new surface float was 135 cubic inches, and its weight, with flag, 0.85 pounds. Deducting this weight from 4.87 pounds (the weight of pure water the above volume would displace if submerged), we have about 4 pounds for its buoyancy in river water. The displacement by subfloat when submerged was about 73.5 cubic inches, corresponding to a buoyancy of 2.65 pounds. Its weight in air was 5.7 pounds, hence weight in water, or the pull it exerted on cord, was about three pounds. The increasing density of water as depth increased diminished this tension slightly when subfloat ran deep.

To maintain surface float in a vertical line through its subfloat, though desirable, appears impracticable. But a tension of nearly 3 pounds on the cord possibly reduces the error due to curving or obliquity of cord to within very small limits.

Although the weight of authority appears to favor a subfloat of about the same density as water, several reasons appeared to require a deviation from this principle in their construction. The great importance of a possibility of locating the position of subfloat from that of its surface float, not only in a horizontal plane, but as to depth as well, demands a tension on the cord to resist its tendency to variation from a vertical line due to different velocities, or the effect of wind on surface float. It also necessitates weight in subfloat (in water) to counteract the effect of upward currents. Without these conditions a loss of control over surface float results. While it is not presumed that a tension of 3 pounds will give the best results, in the absence of proof to the contrary it was adopted; and is probably too small rather than too great.

The excess of one pound in buoyancy of surface float over that necessary to sustain the subfloat ordinarily was found beneficial in resisting the increased tension of cord due to downward currents. Also, should any of the air-chambers spring a leak, or other accident occur to increase tension, this excess of buoyancy would in many cases prevent submergence of surface float.

The three forms of floats mentioned above are represented on Plate II.* Also a diagram showing hypothetical position of floats in the water, and the effect on surface float of a lateral pull on cord. The cord being eccentrically attached to surface float, a lateral pull on cord turns the more acute cone towards the resistance met by surface float, and thereby reduces this resistance to a minimum.

TRANSIT AND OTHER INSTRUMENTS.

For measuring horizontal angles in locating the positions of soundings and floats, transit instruments were used, which read on horizontal limb, by vernier to one minute, Heller and Brightly, Philadelphia, makers.

Signals between transitmen were transmitted by key and sounder, through wire operated by two small "gravity-battery" cells.

Time was noted by an Auburndale timer. This is a stop-watch, marking quarter seconds.

Sounding-line was hempen cord 0.25 inches diameter for 12 pounds lead, and 0.35 inches for 20 pounds lead. For depths greater than 30 feet the latter weight was used. Line was graduated to feet, tenths being estimated by the eye.

WATER-GAUGE.

A water-gauge was established on the Arkansas side near station, whose zero was 4.40 feet below the zero on United States Engineer gauge at Memphis, and 33.90 feet below

* Not printed.

a bench-mark near the gauge, about 750 feet below station and near the edge of bank. This B. M. is the top of a large nail in a notch cut in a cottonwood tree.

The above reference to Memphis gauge was arrived at by a line of levels from B. M. at station to a United States Engineer B. M. corresponding to 32.56 feet, Memphis gauge, and to 36.96 feet on gauge at station. This B. M. was located by United States Engineers' survey of 1877 and 1878, and is situated about 3,000 feet above the station on the levee.

Two readings of the gauge were taken daily at 7 a. m. and 5 p. m., respectively, from December 7 to June 30, as given in the accompanying tables. The corresponding hydrograph is figured on Plate I. An estimated average force and direction of the wind during each day between the morning and evening readings of the gauge is also included in this table. The force is expressed in units of a scale ranging from 0 to 10, 0 representing a calm, and 10 the force of a hurricane.

MANNER OF OBTAINING SOUNDINGS.

Three parallel sections across the river, 100 feet apart, and perpendicular to the general direction of the current, were marked by posts on the bank. They are designated on the accompanying map by the letters A, B, and C at their extremities. From the point A, on the upper section, and near the edge of bank on Arkansas side, a base line of 815.5 feet long was laid off, having its lower extremity, C, also near the edge of bank and commanding a full view of the river in the vicinity of sections. This apparently odd length of base was taken in order that the perpendicular from its lower end to the line of upper section should be 800 feet. On account of the difficulty experienced in attempting to locate small objects on water surface at a distance so great as the width of river, a second base was established on Tennessee side 1,016.3 feet in length, and fulfilling the same conditions as the first, except that the perpendicular to the line of upper section was 1,000 feet. An even hundred feet was adopted for these perpendiculars to facilitate plotting points, located from bases, by means of tangents and cotangents.

When a set of soundings was to be taken an observer with transit instrument was stationed at each end of one of the bases. A skiff, with recorder, leadsman, and three oarsmen, was placed above upper section, bow up stream, and on same side of river as that occupied by observers.

At the signal "ready," by a flagman standing near observer at A, the skiff was allowed to float with the current, oars being out of water except when necessary to keep bow up stream. When observer at A, whose telescope had been directed on line of upper section, observed that flag carried by recorder, in the stern of skiff, was on the section, he indicated the same to flagman near by, who at once signaled to the recorder in skiff. This signal was repeated by recorder by dropping his flag who, at same time, called to leadsman, stationed about three feet in front of him, to "sound." The leadsman, having dropped the lead some time before, carrying it near and "feeling" the bottom as he approached the section, was in position to take a good sounding immediately on hearing call from recorder, and within a very short distance of the section, if not on it. This was done, and depth given by leadman repeated by recorder, and recorded. The lower observer, whose telescope had been directed on recorder's flag, as skiff moved toward section, arrested the motion of his telescope when that flag dropped, read angle his line of sight made with direction of sections and recorded it.

As skiff moved on toward middle section both telescopes were made to follow recorder's flag, lead was carried near bottom, flagman on bank moved to line of middle section, and without aid of an instrument noticed and signaled, as before, the crossing of section by recorder's flag. This signal was repeated by recorder, a sounding was made and recorded, both observers arrested the motion of their telescopes and noted angles.

A sounding was made on lower section in the same manner in every respect as on the middle one.

As soon as skiff passed the lower section it was started up stream preparatory to a repetition of the same operation at another place. After soundings had been taken over about half of the three sections in this manner, observers and flagman occupied corresponding positions on the other side of river until that day's set of soundings was completed.

The sounding line was invariably placed in water several hours before it was used, and its length was carefully tested before commencing operation, one or more times during the day, and after the day's work was completed.

The proper corrections were then applied to the recorded depths to obtain the actual depths. When the line was new the maximum change of length during a day was 0.6 feet. Later the change was very small.

Although three oarsmen sufficed for this work, they were barely able to stem the cur-

rent during the higher stages of the river and permit the taking of so many soundings in one day. The crew working during the first half day were relieved by another, who completed the day's work. As the two crews were necessary in float observations (as explained hereafter) this relief required no extra force. So strong was the current that even with this changing of crews, only superior oarsmen could have accomplished so much.

It was found that a light wind across stream would carry the skiff so far out of the vertical plane through the lead and parallel to direction of current, that quite a perceptible lateral inclination of the line resulted, and greater depths were recorded than actually existed. To avoid error on this account subsequent soundings were only taken on comparatively calm days. This precaution avoided also a portion of the error due to curving of the line in the vertical plane above mentioned, though that curving is probably due principally to different velocities in the plane beneath the surface.

After March 10 only the middle section was determined instead of the three, and soundings on it were taken on the same manner as previously. The reason for the above change will be given hereafter.

The accompanying tables of soundings include all, except the first set taken on the three sections, which are not regarded as sufficiently reliable on account of inexperience of leadman.

TO FIND THE AREA OF DISCHARGE.

The locations of all the soundings taken in a set on each section were plotted to a convenient scale by means of tangents and cotangents. From these, profiles of the three sections were constructed, all referred to the same datum line. If the plotting located any sounding so far from the line of section to which it belonged that its use might be regarded as introducing an error into the resulting profile, it was rejected. This rarely happened however.

Profiles of the three sections determined on the same day are grouped together on Plate III* showing the difference in river bottom at the sections on each day soundings were taken on them.

A mean of the three profiles thus obtained was then interpolated on the diagram, the middle section being given double weight in the interpolation. The area included between this profile and the water line was taken as area of discharge for the day on which soundings were taken.

It was observed that this area so nearly coincided with that of the middle section that it was concluded after March 10 to take the area of middle section for the area of discharge; and, as previously stated, soundings were only taken on that section after that date. This change diminished the labor of sounding greatly, while it, at the same time, increased the accuracy of profile of river bottom, as so many more soundings could be taken on a single section.

METHOD OF FINDING VELOCITIES OF CURRENT.

As previously stated, the only means used for determining velocities were those in which double floats were employed. The method was the same whichever of the three forms of floats was being used.

When a set of current velocities was to be obtained, an observer with transit instrument, stop watch, signal key, and sounder, occupied station A as in observing for soundings. The stop watch was so placed that the observer could strike the signal key by the same motion of the hand made in starting the watch, so that both operations could be performed simultaneously. A second observer with transit instrument, signal key, and sounder, occupied a station C on line of lower section near edge of bank and on same side of river as first observer. These two stations were connected by a complete wire circuit through which signals were transmitted.

A skiff with recorder, three oarsmen, and a convenient number of floats was anchored near and above upper section. Another skiff carrying three oarsmen and the leadman, before mentioned, was stationed below lower section. The length of cord on each pair of floats was marked on the floats so that recorder could readily note the depth at which any subfloat would run.

At a signal from observer at A recorder dropped a float into the water, having first recorded depth marked on float. When observer at A, whose telescope was directed on his section, observed the float cross the section he started stop-watch, at same instant struck signal key, then directed telescope on float and followed it. On hearing his sounder mark the signal given at station A the observer at C, whose telescope had been follow-

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*Not printed.

ing float, arrested its motion and noted the angle its line of sight made with the direction of sections. As a check on reading stop-watch he also noted time by a small clock. He then directed telescope on his section. When float crossed his section he struck signal key and noted time. Observer at A, on hearing sounder mark signal given at C, arrested motion of telescope, at same instant stopped watch, then noted interval of time required for float to pass from upper to lower section, as indicated by watch, and the angle made by line of sight of telescope with direction of sections. After passing lower section the float was picked up by man in lower skiff.

This was repeated with other floats until a float had been run at each five feet of depth, and sometimes in low water at closer intervals. The upper skiff was then moved to a new position and anchored as before; the lower skiff in the mean time returning the floats dropped from the former position.

This operation was repeated until the desired number of groups had been observed, or until darkness stopped the work.

When half of river on that side occupied by observers had been worked over in this way observers moved to the other side, occupying stations corresponding to those vacated. At this time, to equalize labor, the oarsmen above sections exchanged places with those below.

To expedite the transfer of floats from lower to upper skiff the latter was anchored as near the upper section as permissible, and at same time to allow subfloat sufficient time to attain its proper depth before reaching section. By a series of experiments it was ascertained that the time required for the last form of float used to reach a depth of 40 feet was about 15 seconds.

The velocity of each float was obtained by dividing 200 (the distance in feet between upper and lower sections) by the number of seconds required to pass from one section to the other. Whether they moved on a line perpendicular to sections or not, this gave the velocity in feet per second, used in determining the discharge, the object being to find mean velocities in a direction perpendicular to the area of discharge, instead of the actual velocities of particles or slender filaments in their variety of curving motions, either in a horizontal or vertical direction.

Although it was the intention from the beginning to run floats at intervals of about 200 feet across the river and at each 5 feet of depth, this anticipation was not realized until after some weeks of practice, but was eventually fully accomplished. The width of river was divided into 23 divisions of 200 feet each, commencing at a point (A on map*) on line of upper section 26 feet beyond station A. Divisions I and XXIII were not full length on water line, and they varied, of course, with each change of water gauge.

In order that a set of floats from same anchorage might be run as near the middle of a division as conveniently possible, the anchorage was made accordingly. The judgment of recorder aided by signals from observer at lower station (C) gave very good results in this regard.

To find mean velocities in each division:

To determine which division floats passed through, the points where they crossed upper and lower sections were plotted by tangents. The resulting diagrams showed that all the floats dropped from the same anchorage did not move in the same vertical plane, but varied sometimes from a mean position as much as 10 feet on either side at upper, 15 feet at middle, and 25 feet at lower section. Usually they ran within much closer limits. The paths described sometimes crossed each other, at other times were nearly coincident, or parallel. Inasmuch as the interval of time was considerable between the running of two successive floats, it was supposed that the fact of all not being actually in the same plane, was not as objectionable to their being taken as the velocities in that plane at a certain time, as the long interval of time covered in observing them. They were accordingly treated as though they had been taken simultaneously and moved in the same vertical plane perpendicular to the area of discharge.

The velocities obtained from each anchorage were plotted on cross-section paper, the coördinates of each point being the velocity and depth of float. In this manner points were located for each 5 feet of depth, or oftener, for each division separately. If a velocity had not been obtained at a regular depth interval, or if none in a division, they were supplied by interpolation, by drawing a free-hand curve through points at same depth determined for other divisions in the vicinity, on a properly constructed diagram.

Through each set of points thus plotted, or interpolated, a free hand curve was traced and produced downward in its natural course until it intersected a horizontal line drawn at a depth corresponding to that of the river bottom at the place where the set of floats crossed the middle section. The ordinate of this intersection was used as the bottom velocity, and the curve just described was regarded as the vertical velocity curve.

While it is not claimed that the intersection above mentioned gave the actual velocity

*Not published.

at the bottom, in the absence of better information its ordinate was taken as such; a study of velocities obtained near the bottom appears to show that its adoption can troduce but a very small error into the resulting mean velocity for such vertical cur Again, this vertical curve is evidently not the same as would have been obtained h the velocities been taken simultaneously, yet the use of it may possibly be as approp ate in determining the discharge for any day. If not only the velocities in a sin curve could be taken at the same instant but in all the curves included in a compl set, then the discharge for that instant could be arrived at quite closely; but when time required to make the observations for a complete set covers a period of from five ten hours but little advantage can be expected, so far as getting the true discharge concerned, through simultaneous observations for velocities in a vertical plane.

Ordinates were drawn to these curves at each tenth of depth, representing velocit at such depth. From these the mean velocity of each curve, or each division, was fou by adding to the half sum of surface and bottom velocities all the intermediate ones dividing the result by ten.

When more than one velocity was obtained at a given depth in a division their me was used in determining the vertical curve for that division.

During the progress of operations it was discovered that a shorter method of arrivi at the mean velocity in a division gave results so nearly the same as that just explain and that the error, if any, introduced by the change in the discharge was less th that arising from inaccuracies in sounding and the changes in river bottom from day day or hour to hour. It was consequently adopted and employed during the last tw months of observation.

This method consisted in finding the area of velocity curve, determined as before and dividing it by total depth of river where the set of floats crossed the middle section To find this area, a mean of the observed velocities and those interpolated, if any, in division was multiplied by the depth at which deepest float was run. In getting thi mean the surface and deepest observed velocities were given half the weight of each in termediate one. To the area thus obtained was added the small area included betwee the ordinate of deepest observed velocity and that representing bottom velocity. Thi area was obtained by multiplying the half sum of bottom velocity, determined as before and deepest observed velocity by the distance from deepest float to river bottom. Fo the end divisions other methods were used, depending on the number of floats run i them and the profile of bottom near the banks.

These computations were made at the station as data was collected. This accounts for the use of both methods in determining mean velocities, instead of the shorter method only. Such computations were not, however, permitted to interfere with a proper prosecution of the field work.

TO FIND DISCHARGE FROM MEAN VELOCITIES.

On a diagram of the mean of the three sections, or of the middle one when it alone was used, the divisions of 200 feet, before mentioned, were marked off by vertical lines dividing the section, or area of discharge, into twenty-three partial areas, corresponding to the twenty-three divisions for which mean velocities had been determined. These areas were computed to within a nearer approximation to accuracy than it was possible to construct the profiles on account of inaccuracies in sounding and the constant shifting of material on river bottom.

The partial areas are shown on Plate IV.*

To find discharge on any day upon which floats were observed, the partial areas, as found from the last set of soundings obtained previous to the day on which discharge was desired, were corrected for difference of water-gauge on the two days. The product of each such area in square feet by the mean velocity in feet per second, in that division, gave the discharge in cubic feet per second for each division. Their sum gave the total discharge for the day, or time covered by the observations, in cubic feet per second.

This divided by total area of section gave the mean velocity of river. The extreme velocities found in this way were on May 28, 3.107 feet per second; and January 23, 4.873 feet per second.

A set of tables containing the mean velocities and partial discharges for each day float velocities were observed, also a set giving a summary of total discharges are appended.

Extreme discharges were found on May 28, 235576 cubic feet per second; and January 24, 837991 cubic feet per second.

On Plate 1 is a diagram of discharges arranged for a comparison with other results; also a diagram of mean velocities of river similarly arranged.

*Not printed.

MEMORANDUM IN REGARD TO TABULATION OF DISCHARGE OBSERVATIONS AT HAMPTON LANDING, ARKANSAS.

The data for this tabulation have been taken from the tables accompanying a report upon Observations for Discharge and Sediment on the Mississippi, White, and Red Rivers, by W. H. H. Benyaurd, Major of Engineers.

The gauge-readings on days when areas or velocities were measured have been taken directly from the tables; on other days the means of readings, taken at 7 a. m. and 5 p. m., have been taken.

The rise or fall in the preceding 24 hours has been computed from the gauge record, using the morning readings.

The measured water areas, datum areas, mean depths and widths have been taken from the tables, and pertain to section B. Mean datum depths have been computed by dividing the datum areas by 4573 feet, assumed to be the datum width. Maximum depths have been computed from the given soundings, which are referred to the 30-foot stage, by making the necessary corrections for stage.

The interpolated water areas, mean velocities, discharges, and direction and force of wind have been copied directly from the tables.

L. L. WHEELER.

OCTOBER 12, 1886.

Discharge Observations at Hampton Landing, Ark.

[Method: Double floats.]

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1878.	Feet.	Feet.	Sq. ft.	Sq. ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft.	Feet.	Cub. ft.	
Dec. 8	19.0											
9	19.75	+0.9										
10	19.8	+0.1										
11	19.65	−0.1										
12	19.4	−0.3										
13	19.4	0.0										
14	19.7	+0.2										
15	20.05	+0.4										
16	20.3	+0.3										
17	20.3	0.0										
18	20.05	−0.2										Calm.
19	19.9	−0.2										Down, 1
20	19.95	0.0										Across, 2
21	20.1	+0.2										Down, 3
22	20.15	+0.1										Calm.
23	20.0	−0.2	133,306	183,816	30.5	40.2	37.2	4,534				Up.
24	19.6	−0.3										Down.
25	19.0	−0.5										Down.
26	18.1	−0.9										
27	16.9	−1.1	123,618							3.927	485,396	Down, 2
28	15.2	−1.6	116,696							3.979	464,274	Up, 1.
29	13.5	−1.8										Across, 2
30	11.65	−1.7										Calm.
31	10.0	−1.9	90,475	180,675	20.4	39.5	28.2	4,441	−3,141			Across, 1
1879.												
Jan. 1	8.7	−1.2										Down.
2	7.55	−1.4										Down, 3
3	6.9	−0.5										Down, 2
4	6.2	−0.6										Down, 1
5	5.4	−0.8										Down, 2
6	4.3	−1.2										Across, 3
7	3.5	−0.8										Across, 3
8	2.75	−0.9										Across, 3
9	2.2	−0.5										Calm.
10	1.85	−0.4										Down, 1
11	1.65	−0.3										Down, 2
12	2.05	+0.4										Calm.
13	2.65	+0.5										Down.

Discharge Observations at Hampton Landing, Ark.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1879.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Sq. ft.*	*Feet.*	*Cub. ft.*	
Jan. 14	4.15	+1.3										Calm.
15	6.45	+2.1										Up, 3
16	9.45	+3.0										Down, 2
17	12.05	+2.6										Down, 2
18	13.8	+2.3	109,851	183,210	24.5	40.1	30.0	4,483	+2,535			Down, 2
19	16.0	+1.8										Down, 4
20	18.2	+2.1										Up, 5
21	20.4	+2.1										Up.
22	23.0	+2.6	156,706	188,573	34.4	41.2	40.6	4,553	+5,363			Up, 5
23	25.0	+2.3	166,065							4.873	809,239	Calm.
24	26.4	+1.4	172,442							4.860	837,991	Calm.
25	27.25	+1.0										Calm.
26	27.8	+0.6										Down, 3
27	28.2	+0.4										Up, 2
28	28.45	+0.3										Up, 1
29	28.6	+0.2										Up, 1
30	28.5	—0.1	187,365	194,210	41.0	42.5	47.6	4,569	+5,637			Down, 1
31	28.1	—0.3										Down, 6
Feb. 1	27.45	—0.6										Down, 5
2	26.7	—0.8	178,583							4.543	811,256	Calm.
3	25.9	—0.7										Up, 5
4	25.4	—0.6										Down, 3
5	25.4	—0.1	172,664							4.503	777,568	Down, 3
6	25.3	—0.1	172,209							4.546	782,935	Down, 3
7	25.3	0.0	172,209							4.541	781,909	Calm.
8	25.7	+0.3	174,030							4.601	800,759	Calm.
9	26.2	+0.5										Calm.
10	26.65	+0.4										Up, 6
11	26.95	+0.4										Up, 5
12	27.0	+0.1	179,948							4.587	825,454	Up, 3
13	26.7	—0.2										Down, 6
14	26.15	—0.5										Down, 4
15	25.4	—0.7	172,664							4.471	772,011	Down, 1
16	24.25	—1.1										Calm.
17	23.1	—1.1										Down, 3
18	21.5	—1.4	149,671	188,338	32.9	41.2	39.4	4,544	—5,872			Across, 1
19	19.8	—1.8	141,921							3.976	564,297	Up, 2
20	18.2	—1.6	134,682							3.985	536,654	Down, 1
21	17.0	—1.4	129,269							3.826	494,608	Up, 2
22	16.6	—0.6										Up, 6
23	17.15	+0.4										Calm.
24	17.7	+0.6	132,404							3.960	524,384	Up, 2
25	18.35	+0.6										Up, 5
26	18.75	+0.5										Down, 4
27	19.0	+0.3	138,296							4.110	568,398	Calm.
28	19.1	+0.1	138,749							4.129	572,930	Up, 3
Mar. 1	18.95	—0.1										Up, 2
2	18.7	—0.2										Down, 4
3	18.25	—0.5										Down, 2
4	17.8	—0.4										Calm.
5	17.5	—0.4	131,505							3.934	517,325	Calm.
6	17.2	—0.3	130,145							3.925	510,807	Up, 1
7	17.1	—0.1	129,691							3.817	495,065	Calm.
8	17.0	—0.1										Up, 4
9	17.0	0.0										Up, 4
10	16.9	—0.1										Up, 4
11	16.8	—0.1	126,121	186,128	27.9	40.7	34.1	4,500	—2,210			Down, 1
12	16.4	—0.3	124,319							3.931	488,665	Down, 1
13	16.1	—0.3	122,967							3.955	486,306	Calm.
14	16.05	—0.2										Down, 3
15	16.35	+0.3										Down, 4
16	17.15	+0.7										Down, 3
17	18.05	+0.8										Down, 5
18	19.05	+1.0										Down, 1
19	19.8	+0.9	139,696							4.157	580,776	Calm.
20	20.45	+0.6										Up, 5
21	21.2	+0.7	146,062							4.279	625,062	Down, 2
22	21.8	+0.7	148,791							4.351	647,363	Down, 2
23	22.25	+0.5										Calm.
24	22.5	+0.8	155,598	189,795	34.1	41.5	40.7	4,558	+3,667			Across, 3

Discharge Observations at Hampton Landing, Ark.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.							
			Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1879.	Feet.	Feet.	Sq. ft.	Sq. ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft.	Feet.	Cub. ft.	
Mar. 25	22.9	+0.3	157,422							4.270	672,243	Up, 1
26	23.5	+0.5										Up, 5
27	24.1	+0.7										Calm.
28	24.6	+0.5	165,182							4.444	734,051	Up, 2
29	25.05	+0.5										Up, 5
30	25.2	+0.1										Down, 5
31	25.2	+0.1										Up, 5
April 1	25.15	0.0										Down, 4
2	25.1	−0.1	167,464							4.356	729,447	Up, 1
3	24.85	−0.2										Down, 4
4	24.7	−0.2										Down, 5
5	24.5	−0.1	164,722							4.367	719,351	Calm.
6	24.5	−0.1										Up, 5
7	24.7	+0.2	164,752	183,916	33.1	41.3	44.5	4,566	−870			Down, 3
8	24.75	0.0										Calm.
9	24.8	+0.1										Across, 6
10	24.75	0.0										Up, 6
11	24.3	−0.4										Down, 4
12	23.7	−0.5	160,192							4.230	677,640	Calm.
13	23.2	−0.6										Calm.
14	22.9	−0.4										Up, 5.
15	23.3	+0.3	158,368							4.216	667,716	Calm.
16	23.85	+0.5										Down, 4
17	24.3	+0.6										Down, 4
18	24.45	+0.1										Down, 5
19	24.6	+0.2										Up, 4
20	24.5	−0.1										Down, 4
21	24.35	−0.1										Up, 4
22	24.0	−0.3										Up, 6
23	23.6	−0.4	159,736							4.272	682,429	Up, 2
24	22.8	−0.5	156,111							4.205	656,483	Up, 1
25	22.4	−0.5	154,294							4.118	635,306	Calm.
26	21.75	−0.7										Calm.
27	20.9	−1.0										Across, 4
28	19.9	−0.7	142,970							4.032	576,409	Down, 1
29	18.7	−1.4	137,632							3.894	535,902	Calm.
30	17.7	−1.1	125,421	181,379	27.8	39.7	35.6	4,514	−7,537			Calm.
May 1	16.7	−0.9										Down, 4
2	15.7	−0.9	116,431							3.738	435,220	Down, 1
3	14.75	−1.0										Up, 6
4	13.8	−1.0										Up, 2
5	13.0	−0.9	106,938	184,011	23.9	40.2	31.5	4,472	+2,632			Calm.
6	12.05	−0.9										Down, 3
7	11.25	−0.8										Down, 3
8	10.6	−0.7	96,234							3.417	328,866	Down, 1
9	9.9	−0.7	93,112							3.358	312,182	Calm.
10	9.3	−0.5	90,447							3.207	290,044	Up, 2
11	8.85	−0.6										Up, 2
12	8.5	−0.3										Up, 3
13	8.2	−0.3	85,135	183,563	10.3	40.1	25.4	4,413	−448			Up, 1
14	8.2	−0.1	85,135							3.178	270,518	Up, 1
15	8.0	−0.2	84,253							3.158	266,067	Up, 1
16	7.9	−0.1	83,812							3.234	271,011	Down, 2
17	7.8	−0.1	83,371							3.210	267,618	Calm.
18	7.55	−0.2										Calm.
19	7.3	−0.2	80,174	182,573	18.2	39.9	23.7	4,402	−990			Calm.
20	7.2	−0.2	79,734							3.169	252,647	Calm.
21	7.1	0.0	79,294							3.220	255,328	Calm.
22	7.1	−0.1	79,294							3.220	255,342	Down, 1
23	7.0	−0.1	78,853							3.231	254,786	Calm.
24	6.75	−0.2										Up, 4
25	6.45	−0.3										Calm.
26	6.2	−0.2	76,699	183,933	17.5	40.2	23.9	4,395	+1,360			Calm.
27	6.1	−0.2	76,260							3.112	237,343	Calm.
28	6.0	0.0	75,820							3.107	235,576	Calm.
29	6.0	−0.1	75,820							3.115	236,163	Up, 2
30	6.0	0.0										Up, 4
31	6.1	0.0										Up, 4
June 1	6.45	+0.3										Across, 4

Discharge Observations at Hampton Landing, Ark.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1879.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Sq. ft.*	*Feet.*	*Cub. ft.*	
June 2	7.05	+0.6										Down, 4
3	7.6	+0.6	81,993	183,064	18.6	40.0	24.8	4,410	—809			Calm.
4	8.4	+0.8										Up, 3.
5	9.0	+0.6	88,177							3.397	299,542	Up, 1.
6	9.5	+0.5	90,393							3.572	322,922	Calm.
7	10.0	+0.5	92,618							3.528	326,757	Down, 1
8	10.65	+0.6										Calm.
9	11.0	+0.5	97,696	183,749	21.9	40.2	27.4	4,453	+685			Calm.
10	11.1	+0.1	98,142							3.526	346,079	Calm.
11	11.0	—0.1	97,696							3.526	344,475	Up, 1.
12	10.9	—0.1	97,250							3.538	344,060	Calm.
13	10.8	0.0	96,805							3.593	347,844	Calm.
14	10.7	—0.2	96,359							3.448	332,283	Up, 1.
15	10.35	—0.3										Up, 2.
16	10.1	—0.3	93,698							3.571	334,568	Down, 1
17	9.9	—0.2	91,977	183,019	20.7	40.0	26.9	4,444	—730			Down, 1
18	10.0	+0.1	92,422							3.606	333,250	Down, 2
19	10.0	0.0	92,422							3.551	328,184	Down, 1
20	9.9	—0.1										Up, 2.
21	9.8	—0.1	91,533							3.414	312,443	Up, 2.
22	9.85	0.0										Down, 1
23	10.0	+0.2	92,422							3.484	321,982	Across, 1
24	10.5	+0.4	94,640							3.593	340,107	Up, 1.
25	10.9	+0.5	96,437							3.575	344,751	Up, 1.
26	11.25	+0.3										Up, 2.
27	11.1	0.0										Up, 3.
28	10.85	—0.3										Up, 3.
29	10.6	—0.2										Down, 3
30	10.35	—0.3										Down, 2

APPENDIX B.

REPORT OF CAPTAIN THOMAS TURTLE, CORPS OF ENGINEERS, SECRETARY OF COMMITTEE ON CONSTRUCTION.

THE MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE COMMITTEE ON CONSTRUCTION,
2653 *Olive Street, Saint Louis, Mo., June* 30, 1886.

SIR: I have the honor to submit the following report of the work of this office for the fiscal year ending June 30, 1886:

Capt. J. H. Willard, Corps of Engineers, on duty in charge of this office since April 11, 1884, was only relieved by me on June 19 last, so my connection with the committee is simply to record thus summarily the operations for the year, and I shall soon transfer the duties to my appointed successor, Lieut. James L. Lusk, Corps of Engineers.

The suspension of work upon the river, because of the failure of appropriations in the session of Congress ending March 3, 1885, has reduced operations to such as are necessary for the care of the plant, and to such work in the office as could be performed with the small force permitted under the circumstances.

At the time of the last annual report the general-service plant was laid up in harbor at Twin Hollows, about 15 miles below Saint Louis, where it remained till the end of October, 1885, when the filling of the harbor by sediment under the action of the works at that point compelled its removal to some other locality. After examination the bight at Chester was chosen, permission having been obtained from the owners of the adjacent land to occupy about 2,000 feet along the shore. The fleet has remained there since that time, and, with constant work sparring off and ice-cutting along the shore, escaped injury during the very inclement winter season of 1885–'86.

The whole of the commission fleet and a part of the general-service fleet were torn from moorings by a tornado on May 11 and carried across the river and down Mary Chute. The property was finally landed by the tow-boat R. S. Hayes, of the Mississippi Valley line, and was returned to harbor by the Minnetonka.

The roof of the steamer Mississippi has been entirely recovered, and that of the Minnetonka has been repainted and sanded; it was expected that the latter would be renewed last spring, but want of funds has prevented this.

Three thousand one hundred and sixty-five yards of stone were purchased in November for use at Hopefield Bend for 50 cents per cubic yard, loaded on the barges, and the expenses of delivery brought its cost to about 91 cents per cubic yard at the work. Eighty-five cents would probably be a fair average under the conditions of active operations. In this service, barge 187 struck a submerged pile, and, sinking, became a total loss.

During the year the following services have been performed by the steamers: The Commission were carried on a tour of inspection of the works upon the river from Keokuk to New Orleans in November by the Mississippi, and three barges were taken from Red River, and one pile-driver from Vicksburg, to Wilson's Point on the return trip.

The Minnetonka, in November and December, towed the stone purchased at Chester to the work at Memphis; in February assisted in collecting the fleet of United States boats torn away by ice from moorings at Carroll's Island; brought back the commission fleet and that portion of the general-service fleet blown away by the tornado of May 11, and at the end of the year was engaged in towing stone from Chester to Memphis. This stone was for use in work of bank protection undertaken by citizens of Memphis, and for which the use of the needed Government plant was permitted by the Secretary of War.

Attention is respectfully invited to Captain Willard's report of last year in reference to the advantages of the ownership of its plant by the United States, and to the increase of the same, to the best model of barge for carrying stone, to the purchase of Illinois coal, and to the building of the new tow-boats. The recommendations are, of course, to be considered in connection with the amount of the next appropriation and its application.

The working drawings are prepared complete for two iron and steel hulled tow-boats; the one 180 feet long, 30-feet beam, and 5 feet 8 inches depth of hold; the other 135 feet long, 26-feet beam, and 5 feet hold. Thorough surveys have been made of the existing wooden-hulled tow-boats, Minnetonka, Osceola, and Emma Etheridge, and drawings in full detail are made of the first and second, and those of the last are under way.

The expenditures for general service are apportioned among the districts according to the work done; those for outfit and repairs and for care of plant are divided equally among the first, second, and third.

The amount available for general service July 1, 1885, was $127,809.68, of which $20,527.75 has been expended and $17,036.80 charged to districts; $7,600 transferred to Plum Point, $33,900 to Memphis Reach, $29,215.04 to Lake Providence Reach, $250 to Vicksburg Harbor (Delta Point), $4,000 to New Orleans Harbor, $10,500 to mouth of Red River, and $1,000 to Tensas Front Levee (fourth district).

The balance available July 1, 1886, is $20,816.89.

I present herewith directory of the commission, with its officers and districts under improvement, estimates for general service 1886–'87, statement of plant, detailed statement of expenditures by the general service, detailed financial statement of all expenditures from July 1, 1885, to June 30, 1886, and a general statement of appropriations and expenditures from March 3, 1881, to June 30, 1886.

THE MISSISSIPPI RIVER COMMISSION.

Col. and Bvt. Maj. Gen. Quincy A. Gillmore, Corps of Engineers, President, 33 West Houston street, New York.

Lieut. Col. and Bvt. Brig. Gen. Cyrus B. Comstock, Corps of Engineers, Willets Point, New York Harbor.

Maj. Charles R. Suter, Corps of Engineers, 1415 Washington avenue, Saint Louis.

Henry Mitchell, civil engineer, office U. S. Coast and Geodetic Survey, Washington, D. C.

B. M. Harrod, civil engineer, Cotton Exchange Building, New Orleans.

Hon. Robert S. Taylor, P. O. Box 1648, Fort Wayne, Ind.

S. W. Ferguson, civil engineer, Greenville, Miss.

Capt. Thomas Turtle, Corps of Engineers, Secretary, 2828 Washington avenue, Saint Louis.

THE COMMITTEE ON CONSTRUCTION.

Messrs. Gillmore, Comstock, Suter, and Harrod.
Capt. Thomas Turtle, Corps of Engineers, Secretary and Assistant, 2653 Olive street Saint Louis.

Officers of Corps of Engineers in charge of districts.

Districts.	Name and address of officer in charge.	Extent of district.
		Miles.
Des Moines Rapids to Illinois River	Capt. Ernest H. Ruffner, Quincy, Ill.	165
Illinois River to Ohio River	Maj. Oswald H. Ernst, custom-house, Saint Louis, Mo.	245
First district—Ohio River to foot of Island No. 40.	Capt. Smith S. Leach, custom-house, Cairo, Ill., and Elmot, Ark.	220
Second district—Foot of Island No. 40 to White River.	Capt. Smith S. Leach, 280 Front street, Memphis, Tenn.	180
Third district—White River to Warrenton, Miss.	Capt. William T. Rossell, Memphis, Tenn., and Wilson's Point, La.	220
Fourth district—Warrenton to Head of Passes	Maj. Charles W. Raymond, 3 South Rampart street, New Orleans, La.	484

General service estimates, 1886–'87.

One large steel tow-boat	$55,000	
One small steel tow-boat	35,000	
		$90,000
11 coal barges	22,000	
12 small gunwale barges	24,000	
32 large gunwale barges	96,000	
		142,000
General repairs to plant on resuming operations	20,000	
General and extraordinary repairs during year	10,000	
		30,000
		262,000
Running expenses of tow-boats:		
Mississippi, eight months, at $3,400	27,200	
Minnetonka, ten months, at $3,600	36,000	
New large tow-boat, three months, at $3,600	10,800	
New small tow-boat, three months, at $2,400	7,200	
	81,200	
500,000 bushels Illinois coal, on board, at 8 cents	40,000	
		121,200
Office, salaries, rent, and contingencies	12,000	
Administration and inspection	5,000	
Fleet and care of property	4,000	
		21,000
		404,200

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, general service, June 30, 1886.

1 steamer, Mississippi	$54,000
1 steamer, Minnetonka	36,000
1 pump-boat	900
1 store-boat	450
2 sounding-boats	36
28 barges (flush deck)	30,240
27 barges (low deck)	43,560
Office furniture	360
Total value	165,546

Expenditures on account of appropriation for improving Mississippi River, no limit, from allotment for general service, from July 1, 1885, to June 30, 1886.

Plant and outfit	$803 67
Repairs to plant	919 21
Care of public property	6,330 08
Administration and inspection	664 41
Office expenses, rent and repairs	5,217 53
Expenses delivering stone to second district	1,386 21
Expenses steamer Mississippi on tour of inspection	3,490 95
Expense of moving fleet	851 91
Extraordinary expense in breaking up of ice	378 76
Rescuing barges from ice in winter of 1885–'86	96 00
Extraordinary expense during dispersion of fleet by tornado in May, 1886	271 62
Towage and transportation	117 40
Total	20,527 75

The above expenditures are apportioned as follows:

To first district	5,178 53
To second district	6,564 73
To third district	5,178 54
To fourth district	115 00
Unapportioned	3,490 95
Total	20,527 75

Financial statement, July 1, 1885, to June 30, 1886.

General Service:		
Available July 1, 1885		$127,809 68
Transferred to first district	$7,600 00	
Transferred to second district	33,900 00	
Transferred to third district	29,465 04	
Transferred to fourth district	15,500 00	
Expenditures apportioned to June 30	17,036 80	
		103,501 84
Balance		24,307 84
Unapportioned expenditure fourth quarter, 1885		3,490 95
Balance in Treasury	15,026 87	
Balance in hand	5,790 02	
		20,816 89
Des Moines Rapids to Illinois River:		
Available July 1, 1885	86,758 05	
Received from sale of fuel	78 75	
		86,836 80
Expended		59,007 74
Balance in Treasury	15,000 00	
Balance in hand	12,829 06	
		27,829 06
Illinois River to Ohio River and protection of the easterly bank of the Mississippi near Cairo:		
Available July 1, 1885	112,860 03	
Received from sale of fuel	56 17	
		112,916 20
Expended, Illinois River to Ohio River	66,179 29	
Expended, Cairo	5,427 26	
		71,606 55
Balance in Treasury	40,000 00	
Balance in hand	1,309 65	
		41,309 65

New Madrid Reach:		
Available July 1, 1885		$2,138 09
(Transferred to Plum Point Reach).		
Plum Point Reach:		
Available July 1, 1885	$16,505 11	
Drawn from Treasury for general service	5,178 53	
Transferred from general service	7,600 00	
Transferred from New Madrid Reach	2,138 09	
Transferred from Saint Francis Front	126 89	
		31,548 62
Expended		30,021 60
Balance in hand		1,527 02
Saint Francis Front (first district):		
Available July 1, 1885		126 89
(Transferred to Plum Point Reach).		
Memphis Reach:		
Available July 1, 1885	69 24	
Received from sale of fuel	6 67	
Drawn from Treasury for general service	6,564 74	
Transferred from general service	33,900 00	
		40,540 65
Expended		34,738 54
Balance in Treasury	1,400 00	
Balance in hand	4,402 11	
		5,802 11
Memphis Harbor:		
Available July 1, 1885		1,441 53
Expended		210 00
Balance in hand		1,231 53
Saint Francis Front (second district):		
(Allotment expended before July 1, 1885.)		
Survey of Helena Reach:		
(Allotment expended July 1, 1885.)		
Lake Providence Reach:		
Available July 1, 1885	$22,070 45	
Received from sale of fuel	78 75	
Drawn from Treasury for general service	5,178 54	
Transferred from Yazoo Front	171 05	
Transferred from general service	29,215 04	
		56,713 83
Transferred to Tensas Front	2,000 00	
Expended	48,716 98	
		50,716 98
Balance in Treasury	3,215 04	
Balance in hand	2,781 81	
		5,996 85
Vicksburg Harbor (dredging):		
(Allotment expended before July 1, 1885.)		
Vicksburg Harbor (Delta Point):		
Available July 1, 1885	3,682 88	
Transferred from general service	250 00	
		3,932 88
Expended		3,872 29
Balance in hand		60 59

Survey of Unleveed Fronts (third district):
(Allotment expended before July 1, 1885.)

Choctaw Bend Survey:
(Allotment expended before July 1, 1885.)

New Orleans Harbor:

Available July 1, 1885	$596 57	
Transferred from general service	4,000 00	
Transferred from survey Cubitt's Gap	162 86	
Transferred from levee Atchafalaya Front	1,400 00	
		$6,159 43
Expended		4,151 78
Balance in hand		2,007 65

Mouth of Red River:

Available July 1, 1885	3,816 08	
Drawn from treasury for general service	115 00	
Transferred from general service	10,500 00	
Transferred from levees Atchafalaya Front	1,400 00	
		15,831 08
Expended		11,466 65
Balance in Treasury	3,500 00	
Balance in hand	864 43	
		4,364 43

Natchez and Vidalia:

Available July 1, 1885	1,625 95
Expended	625 30
Balance in hand	1,000 65

Observations at Carrollton:
(Allotment expended before July 1, 1885.)

Survey of Unleveed Fronts (fourth district):
(Allotment expended before July 1, 1885.)

Survey of Cubitt's Gap:

Available July 1, 1885	162 86
(Transferred to N. O. Harbor.)	

Levees, (second district):

(*Yazoo Front.*—Allotment expended before July 1, 1885.)
(*Long Lake.*—Allotment expended before July 1, 1885.)

Levees (third district):

Tensas Front:

Available July 1, 1885	32 26	
Transferred from Lake Providence	2,000 00	2,032 26
Expended		32 26
Balance in hand		2,000 00

Yazoo Front:

Available July 1, 1885		174 55
Expended	3 50	
Transferred to Lake Providence	171 05	174 55
Balance		0 00

(*Opossum Fork.*—Allotment expended before July 1, 1885.)

Levees (fourth district):

Atchafalaya Front:

Available July 1, 1885		$9,496 07
Transferred to New Orleans harbor	$1,400 00	
Transferred to Mouth of Red River	1,400 00	
Transferred to Tensas Front	3,400 00	
Expended	2,784 72	
		8,984 72
Balance in hand		511 35

Tensas Front:

Available July 1, 1885	611 76	
Transferred from Atchafalaya Front	3,400 00	
Transferred from general service	1,000 00	
		5,011 76
Expended		3,598 04
Balance in Treasury	1,000 00	
Balance in hand	413 72	
		1,413 72
Total available July 1, 1885 (levees)	10,314 64	
Transferred from Lake Providence	2,000 00	
Transferred from general service	1,000 00	
		13,314 64
Transferred to Lake Providence	171 05	
Transferred to New Orleans Harbor	1,400 00	
Transferred to mouth of Red River	1,400 00	
Expended	6,418 52	
		9,389 57
Balance in Treasury	1,000 00	
Balance in hand	2,925 07	
		3,925 07
Total available July 1, 1885, for improving Mississippi River	389,978 05	
Received from sale of fuel	220 34	
		390,198 39
Expended		274,326 89
Balance available July 1, 1886, to meet liabilities and to carry on work under the Mississippi River Commission		115,871 50

Statement of funds available for improving Mississippi River, from March 3, 1881, *to June* 30, 1886.

Act of March 3, 1881		$1,000,000 00
Act of August 2, 1882		4,123,000 00
Act of January 19, 1884		1,000,000 00
Act of July 5, 1884, less $5,000 transferred to snag-boat service		2,065,000 00
Total specific appropriations		8,188,000 00
Balances from former appropriations applied to works below Cairo under act of August 2, 1882, less $123.42, reverted to Treasury	$272,504 96	
Same for works above Cairo, under act of July 5, 1884	22,632 53	
Total balances		295,137 49
Received from sales and loss of property		631 41
Total available		8,483,768 90
Expended to June 30, 1886		8,367,897 40
Balance available July 1, 1886		115,871 50

Detailed statement of funds applied to improving Mississippi River, under the Mississippi River Commission, from March 3, 1881, to June 30, 1886.

Districts.	From appropriations.	From balances.	From sales.	Total available.	Expended.	Balances in treasury.	Balances in hand.	Total balances.
Des Moines Rapids to Illinois River	$195,000 00	$12,663 38	$122 64	$207,786 02	$179,956 96	$15,000 00	$12,829 06	$27,829 06
Illinois River to Ohio River	470,000 00	9,969 15	126 60	480,095 75	455,518 85	24,000 00	576 90	24,576 90
Protection, near Cairo	50,000 00			50,000 00	33,267 25	16,000 00	732 75	16,732 75
	520,000 00	9,969 15	126 60	530,095 75	488,786 10	40,000 00	1,309 65	41,309 65
Survey Saint Francis Front	4,873 11			4,873 11	4,873 11			
New Madrid Reach	210,361 91		2 83	210,364 74	210,364 74			
Plum Point Reach	2,410,468 04		99 70	2,410,567 74	2,409,040 72		1,527 02	1,527 02
Totals, first district	2,625,703 06		102 53	2,625,805 59	2,624,278 57		1,527 02	1,527 02
Survey Saint Francis Front	4,000 00			4,000 00	4,000 00			
Survey Helena Reach	8,000 00			8,000 00	8,000 00			
Levees:								
Long Lake	15,000 00			15,030 00	15,000 00			
Yazoo Front	80,950 00			80,950 00	80,950 00			
Memphis Harbor	200,000 00		22 50	200,022 50	198,790 97		1,231 53	1,231 53
Memphis Reach	517,586 54		27 14	517,613 68	511,811 57	1,400 00	4,402 11	5,802 11
Totals, second district	825,536 54		49 64	825,586 18	818,552 54	1,400 00	5,633 64	7,033 64
Survey unleveed fronts	1,000 00			1,000 00	1,000 00			
Survey Choctaw Reach	2,679 86			2,679 86	2,679 86			
Levees:								
Opossum Fork	25,000 00			25,000 00	25,000 00			
Yazoo Front	364,878 95			364,878 95	364,878 95			
Tensas Front	413,140 00			413,140 00	411,140 00		2,000 00	2,000 00
Vicksburg Harbor:								
Dredging	61,812 12			61,812 12	61,812 12			
Delta Point	93,736 46	25,770 13		119,506 59	119,446 00		60 59	60 59
Lake Providence Reach	2,294,780 81		218 75	2,294,999 56	2,289,002 71	3,215 04	2,781 81	5,996 85
Totals, third district	3,257,028 20	25,770 13	218 75	3,283,017 08	3,274,959 64	3,215 04	4,842 40	8,057 44
Survey Cubitt's Gap	137 14			137 14	137 14			
Survey unleveed fronts	1,000 00			1,000 00	1,000 00			
Observations at Carrollton	3,000 00			3,000 00	3,000 00			
Bonnet Carre Crevasse	15,000 00			15,000 00	15,000 00			
Natchez and Vidalia Harbors		8,252 04		8,252 04	7,251 39		1,000 65	1,000 65
New Orleans Harbor	7,823 47	147,670 39		155,493 86	153,486 21		2,007 65	2,007 65
Mouth of Red River	23,405 00	90,812 40		114,217 40	109,852 97	3,500 00	864 43	4,364 43

Detailed statement of funds applied to improving Mississippi River, under the Mississippi River Commission, from March 3, 1881, to June 30, 1886—Cont'd.

Districts.	From appropriations.	From balances.	From sales.	Total available.	Expended.	Balances in treasury.	Balances in hand.	Total balances.
Levees:								
Tensas Front	$553,270 00			$553,270 00	$551,856 28	$1,000 00	$413 72	$1,413 72
Atchafalaya Front	136,800 00			136,800 00	136,288 65		511 35	511 35
Totals, fourth district	740,435 61	$246,734 83		987,170 44	977,872 64	4,500 00	4,797 80	9,297 80
General service	24,296 59		$11 25	24,307 84	3,490 95	15,026 87	5,790 02	20,816 89
Grand totals	8,188,000 00	295,137 49	631 41	8,483,768 90	8,367,897 40	79,141 91	36,729 59	115,871 50

THOMAS TURTLE,
Captain of Engineers, Secretary of Committee on Construction.

Gen. Q. A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

APPENDIX O.

REPORT OF CAPTAIN E. H. RUFFNER, CORPS OF ENGINEERS, UPON THE IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE DES MOINES RAPIDS AND THE MOUTH OF THE ILLINOIS RIVER.

UNITED STATES ENGINEER OFFICE,
Quincy, Ill., July 20, 1886.

SIR: I have the honor to submit the following report of operations for the improvement of the Mississippi River from the Des Moines Rapids to the mouth of the Illinois River, Illinois and Missouri, for fiscal year ending June 30, 1886.

Having made a personal inspection of the district, from the 22d to the 26th June, and examined the condition of all works of construction, and also the needs of various points of bad navigation, I recommended that the first work to be done be the repair of three closing dams at and near Slim Island, which were put in in 1879, and now needed considerable repair in order to maintain the existing good condition of the channel and river in this vicinity.

Previous to doing this it was found necessary to repair a break in the shore protection and east end of the closing dam at Denmark Island, covering a distance of 487 feet.

Material used.

Stone	cubic yards	1,238.89
Brush	do	970.61

Total cost, $2,089.02, or about $0.945 per cubic yard.

The repairs of the closing dam between Carroll and Coon Islands, consisting of strengthening the shore protection, and raising the dam to 5 feet above low water, were completed in July.

Material used.

Stone	cubic yards	2,382.48
Brush	do	1,679.00

Total cost, $3,681.29, or about $0.908 per cubic yard.

The repairs to the closing dam between Carroll Island and the Illinois shore were similar in character to the last described. Begun in July, finished in August.

Material used.

Stone	cubic yards	4,846.44
Brush	do	2,005.06
Poles	number	1,592

Total cost $7,212.98, or about $1.052 per cubic yard.

The repairs to the closing dam between Slim Island and the Missouri shore, similar in character to the above, were begun August 29, and completed in September.

Material used.

Stone	cubic yards	3,183
Brush	do	1,834
Poles	number	1,290

Total cost, $4,566.96, or about $0.910 per cubic yard.

On September 20 a closing dam was begun across Westport Chute, about 800 feet below the head of the island. The dam is about 1,100 feet long, and consists of a brush sill 60 feet wide, weighted with gravel, dredged near Hamburg, and on this a dam composed of alternate layers of gravel and stone. Shore protections on Westport Island 800 feet in length, and 500 feet on the Missouri shore, were also placed. The dam was nearly completed by the end of October, and low water forced a suspension of work.

Material used.

Stone	cubic yards	7,412.72
Brush	do	4,248.88
Poles	number	2,465

Dredged material, cubic yards 9,928 of which probably one-half may be considered as remaining in the dam. Total amount of material in the dam, 16,600 cubic yards. Cost

of dredged material, $0.094 per cubic yard; cost of stone and brush, $0.811 per cubic yard; total cost of the work, $10,409.45.

On October 22 a beginning was made towards a closing-dam across the small chute between North and South Fritz Islands. This dam is about 420 feet long, of the same construction as that at Westport Chute, but there being no gravel within a reasonable distance brush was used in the body of the dam. Protection on North Fritz 200 feet in length, and on South Fritz 150 feet below the dam and 450 around the head of the island. This dam was completed in great part and the fleet left November 21 for Cincinnati Landing.

Raising the crest and additional material are needed on the Hickory Island Dam.

Material used.

Stone	cubic yards	3,255.26
Brush	do	1,640.69
Poles	number	1,028

Total cost, $4,161.51, or about $0.83 per cubic yard.

The revetment at Cincinnati Landing, hastily and temporarily put in in 1879, has never been completed, and an attempt was made to do as much as possible before cold weather stopped operations. Most of the work was riprapping simply, but brush was also used.

The old work has been fairly connected, and will now stand.

Material used.

Stone	cubic yards	979
Brush	do	981
Poles	number	271

Total cost, $1,650.95, or about $0.845 per cubic yard.

DREDGING OPERATIONS.

The contract for dredging in Quincy Bay was completed early in August by the contractor, H. S. Brown.

During the execution of this contract there have been dredged in Quincy Bay, principally from the bar at the mouth of Whipple Creek, 81,117.14 cubic yards of material at 14 cents per cubic yard, giving a total cost of $11,504.80. The inspector's salary and the expenses of certain protection work done at the mouth of the creek to restrain its floods, amounted to $994.75, making $12,499.55 for the cost of the improvement of Quincy Bay, and covering, within 45 cents, the original allotment for that purpose, made to conform to the clause in the appropriation bill. To the channel cut through the bar the low-water season did no damage, but the high water of the spring completely reformed the bar. No channel is found there now.

HICKORY CHUTE.

It having been reported to me that only 4.2 feet was found on the bar at the foot of Hickory Chute, the dredge, launch, and dumps were sent there from Westport Chute November 22, and the channel was widened and deepened as a temporary relief. Amount dredged, 4,819.44 cubic yards; cost, $232.46, including only the actual expenses for the actual time.

WYACONDA BAR.

This bar had only 4.5 feet at the lowest stage, and was the most important and difficult question in the district. A wing-dam built above it in 1884, and a closing-dam from the island opposite La Grange to the Illinois shore, built in 1884, below the bar, and a channel dredged through the bar in 1884, did not seem to give a permanent relief.

It was noticed from the surveys, however, made in the fall of 1884, spring and fall of 1885, that the deep curves seemed inclined to work down through the bar so as to give a channel where wanted; and to test it thoroughly the dredge, launch, and dumps were sent there so as to begin work November 2 on the down-river side of the bar. Work was continued without interruption until November 20, when this plant was laid up for the winter. Beginning at a point on the upper end of the cut, where there was a depth of 3 feet below low water, an area was excavated to a depth of 4 feet below low water, about 245 feet wide, and long enough to connect the similar curves above and below the bar. Seven and a half cuts were made, and the average length was about

1,000 feet. Some filling occurred at first, later but little was noticed, and to date it appears to be able to scour out as fast as filled. The set of the current is entirely that way now, the old crossing filling up, and this channel has been maintained and is now in use.

Total material dredged, 16,696.06 cubic yards. Average amount dredged per day, 1,077.2 cubic yards.

Total expenses of the plant while engaged upon this work and of the Coal Bluff for towage, $1,023.79. Average cost per cubic yard excavated, $0.0613.

In the spring, as soon as the weather would permit, arrangements were made, in accordance with approved plans, for beginning work on the repair of the dam at Oyster Island, opposite La Grange.

A party was sent out to cut brush on Cottonwood Island, March 18. On March 22 barges were towed up to La Grange and left to be loaded with stone, and on the following day three mooring mats were sunk above the break in this dam. The opening was found to be about 80 feet wide on top and worn to a depth of 12 feet below low water. A good apron 120 feet long was put in to begin with, and the gap was then substantially filled up with rock and brush to a height of 5.5 feet above low water, having a width of about 8 feet on top. In addition a sufficient quantity of rock was deposited on the dam formerly built for a distance of about 30 feet out from each end of the place repaired to raise the whole to grade.

The whole was completed March 30, and the fleet returned to Quincy and laid up on account of high water.

Amount of material put in.

Stone	cubic yards	1,104
Brush	do	711

After this no work of construction was done except the repair of a break 40 feet wide and 22 feet deep, at a 14-foot stage, in the brush-fence dam opposite Quincy. This was done by driving a row of piles 4 feet apart, and arching up stream and around the break; mats of poles were sunk on the up-stream side so as to reach sufficiently high on the piles, then fascines were sunk perpendicularly, close together, butt-ends, down on the upper side of the pole work; and finally, a mat 70 feet long was sunk close to and at the upper side of the mended gap and for the full length of the new work. A second mat connected this with the piles for a length of 40 feet. The whole was well rocked. Some other weak places in the dam were suitably strengthened.

Total time occupied on the work	days	6½
Total distance run by steam-launch	miles	78
Total stone in place	cubic yards	230¾
Total brush in place	do	120¾
Total piles driven	number	16

Throughout the year the navigable channel has continued good; no detention in navigation has occurred except when and where mentioned in this report.

Financial statement.

Available July 1, 1885	$86,758 05
Received from sale fuel	78 75
	86,836 80
Expended July 1, 1885, to July 1, 1886	59,007 74
Balance available July 1, 1886	27,829 06
Balance in Treasury	15,000 00
Balance in hand	12,829 06
	27,829 06

Very respectfully, your obedient servant,

E. H. RUFFNER,
Captain of Engineers.

Col. QUINCY A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, from Des Moines Rapids to the mouth of the Illinois River.

Class of property.	Value.	Class of property.	Value.
1 steamer, "Coal Bluff"	$13,500	6 dump-boats, at $810	$4,[illegible]
1 launch, "Irene"	1,350	2 quarter-boats, at $360	7[illegible]
6 model barges, at $2,430	14,580	1 quarter-boat	[illegible]
3 model barges, at $900	2,700	5 skiffs, at $15	[illegible]
1 coal-flat	900	Tools and appliances	[illegible]
1 flat	1,000	Surveying instruments	[illegible]
5 flats, at $1,350	6,750	Office furniture	[illegible]
1 pile-driver and tender	1,440		
1 dredge	20,250	Total	70,[illegible]

APPENDIX D.

REPORT OF MAJOR O. H. ERNST, CORPS OF ENGINEERS, UPON THE IMPROVEMENT OF THE MISSISSIPPI RIVER, BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

UNITED STATES ENGINEER'S OFFICE,
Saint Louis, Mo., July 22, 1886.

COLONEL: I have the honor to submit the following report upon the improvement of the Mississippi River between the Illinois and Ohio rivers, for the fiscal year ending June 30, 1886.

At the date of my last report work in the field was suspended; for want of funds little was done during the year. Some extensions and repairs were made at Horsetail, Twin Hollows, east side; Pulltight, Chesley Island, and Jim Smiths.

HORSETAIL.

Work at this place was resumed October 8. All of the old work was in very good condition, with the exception of a small break in hurdle No. 27½, near its outer end. A heavy fill had been made over all the space protected by the hurdles constructed in the spring. The head of Carroll's Island, however, had suffered heavy erosion, leaving the outer end of the hurdle, which formerly connected it with the Illinois shore, exposed. It was necessary to extend this hurdle to a new junction with the island, to repair No. 27½, and to raise the wattling of the new hurdles, which had been left at 8 feet standard gauge, to the full height of the piles. By the 25th of November, when operations were suspended, most of this work had been accomplished.

The Carroll's Island hurdle was extended 2,200 feet, the wattling was carried up to the 8-foot stage upon the new portion, and was completed to the height of the piles upon the portion formerly constructed. Wattling was placed in hurdles 27½, 29½, 31, and 32 to full height except for a short distance, 125 to 150 feet from the outer end of each, where it was left at the 8-foot stage.

All of these new hurdles suffered some damage during the winter and the subsequent high water, but to all except the Carroll's Island hurdle the damages were slight, being limited to the overturning of a few piles at the outer ends. A breach 950 feet long was made in the Carroll's Island hurdle, the piles being fixed in heavy ice and lifted out of position on the rise of over 12 feet, which occurred during the winter. Nothing could be done to repair these damages for want of funds. Over all the reclaimed area at Horsetail, on both sides of the river, the growth of the new banks has continued in a satisfactory manner, the area upon which willows are growing being largely increased.

The least depth of water in the channel reported during the year was 10½ feet.

TWIN HOLLOWS, EAST SIDE.

At two places, near Stations 76 and 81 respectively, where the bank protection had been carried to a height of 8 feet above standard low water, the high water of the previous summer had caused some erosion, getting in behind the mattress work. The protection was partially repaired at these places during October and November, but further work is required near Station 81, which lack of funds has prevented.

PULLTIGHT.

The wattling of the primary hurdle and of secondary hurdle No. 1 was raised from the height 8 feet above standard low water to the height 16 feet above the same plane. The work was begun November 23 and completed November 28.

During the winter and subsequent high water about 850 feet of the primary hurdle

was carried away, and about 15 feet from the outer ends of each Nos. 1, 2, and 4. A large increase has been made to the deposits formerly secured.

The least depth of water in the channel in this vicinity reported during the year was 3½ feet.

CHESLEY ISLAND.

The hurdle constructed in 1883, to close the chute west of the island, had been considerably damaged, and had failed to accomplish its object. A new hurdle, located about 375 feet above the old one, was begun in October and completed early in November, its length being about 670 feet. During the winter a breach about 175 feet long was made near the middle of the hurdle by ice. Except opposite this breach there has been a heavy deposit of solid matter.

JIM SMITH'S.

The large fill caused during the summer by the hurdles which had recently been constructed justified raising the wattling, which was left at 8 feet standard gauge, to the full height of the piles. This was done during October and November. Just above the primary hurdle, where it joins the Illinois shore, the bank was cutting, and required protection. As time and means were both wanting to make that complete, only a temporary protection could be placed. A mattress 300 feet long and 75 feet wide was fabricated, and sunk with its inner edge 8 feet above low-water mark, and some riprap was deposited upon the bank at higher levels.

During the winter and the subsequent high water the hurdles suffered some slight damage, about 5 per cent. being carried away. Very large deposits have been secured.

The least depth of water in the channel in this vicinity reported during the year was 8 feet.

EQUIPMENT.

On Saturday, February 13, the fleet, consisting of 71 pieces, which was in winter harbor in rear of Carroll's Island, about 12 miles from Saint Louis, was torn from its moorings by floating ice and carried down the river. Some of the pieces were sunk and others damaged. The vessels lost were:

Steamer A. A. Humphreys, valued at (after deducting value of machinery and other property saved)	$12,163 45
Old hull of steamer Anita, valued at	....
Hydraulic excavator	6,383 44
Steam launch Florence	650 00
Floating ways for mattresses	1,415 84
Pile driver No. 21	1,562 27
One skiff	16 11
One yawl	30 19
Quarter-boat No. 14	819 00
Quarter-boat No. 6	819 00
Barge No. 10	200 00
Barge No. 23	2,866 69
Five barge flats (old coal barges)	....
Piles loaded upon barges 23 and 30 were lost, valued at	3,335 83
And upon the other vessels were lost tools and appliances and boarding outfit, comprising a large number of articles, valued at	1,927 28
The expense of recovering the property and towing it to harbor at White House, including dockage and repairs of three hulls, were	10,435 93
Making the total loss from the disaster of February 13	42,625 03

Approximate value of plant.

Class.	Value.	Class.	Value.
1 steamer, General Gillmore	$16,592 82	1 ways for mattress	$1,165 85
27 barges, model. } 4 barge flats. }	66,292 91	Tools and appliances	1,260 99
19 pile-drivers	26,358 17	Photographic apparatus	275 00
1 machine-shop, floating	1,535 21	Office furniture	625 62
2 quarter-boats	1,387 98	Surveying instruments	760 84
50 skiffs	668 69	Boarding outfit	13,575 89
45 yawls	1,127 21	Total	135,622 53
115 flats	8,995 85		

NAVIGABLE DEPTH BETWEEN SAINT LOUIS AND CAIRO.

The least depth found in the channel between Saint Louis and Cairo, as reported by pilots, was 5½ feet, and was found at Herculaneum. A depth of but 6½ feet was found at Mary River, Devil's Island, Jacket Pattern, Buffalo Island, and Saladin Towhead. The least depth found for the distance of 22 miles below Saint Louis, over which the works of improvement have extended, was 8 feet, and was found at Jim Smith's.

Money statement.

July 1, 1885, amount available	$106,573 91
Miscellaneous receipts	56 17
Total	106,630 08
July 1, 1886, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1885	65,320 43
July 1, 1886, outstanding liabilities	5,141 52
	70,461 95
July 1, 1886, amount available	36,168 13

Very respectfully, your obedient servant,

O. H. ERNST,
Major of Engineers.

Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

APPENDIX E.

REPORT OF CAPTAIN SMITH S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 30, 1886.

SIR: I have the honor to submit the following report upon the work of improving Mississippi River, first district, for the fiscal year ending June 30, 1886. The period from July 1, 1885, to December 1, 1885, has already been treated in a supplemental report (see Ex. Doc. No. 38, H. of R., 49th Cong., 1st session), and the descriptive part of this report will begin with the latter date.

The only work done during the period was the repair of a small gap at the junction of Osceola No. 4 and Osceola-Bullerton dikes. This corner projected into the river, and had suffered from the impact of drift. Finally a run of ice, in January, 1886, carried away the wreck and a channel cut through the bar from the angle of the dikes directly toward the head of Bullerton Chute. Anticipating a dangerous increase of the pressure on the Bullerton dikes if this action continued, it was decided to close the gap. The work was done in February and March of the present year. It involved the driving of 75 piles and the placing of 46 riders and braces and a foot mat 65 by 175 feet. Exclusive of the value of materials on hand, the expenditures were $551.26.

The effects were immediate and substantial. Before the work was finished deposits began, and when the bar was next exposed the depression was entirely obliterated.

All other expenditures were for the care and preservation of the large amount of public property lying idle, and for the performance of routine office work. The floating and other property pertaining to the first and second districts was collected in Bullerton Chute, on the Plum Point Reach, and placed in charge of a force just sufficient to meet the ordinary exigencies of river and weather, and to give an efficient protection from fire. When the conditions were favorable there was a slight excess both of mechanical and manual labor, which was utilized in such repairs to the various boats as were most urgently necessary. The principal item of repairs was the recalking of the bottoms of all the barges and some of the heavier pieces. A substitute for a lifting dock was improvised from boats and materials on hand and 73 pieces were calked at a less expense, including

the construction and operation of the dock, than would have sufficed to merely tow them to the nearest ship-yard and back.

All work was done by hired labor and the purchase of materials in open market, the quantities desired and the circumstances attending their purchase making it more advantageous for the Government to procure them in that way.

The damage to works since December 1, 1885, is as follows:

A run of heavy ice January 11-18 injured the central portion of the Gold Dust main dike. Early in February a second run of ice inflicted similar damage upon the lower part of this dike. The piles of the front row were cut off at the ice level. At first the riders and braces remained in position, but they have gradually broken down, until now the dike has no resisting power above the 15-foot plane. The stumps of the piles are in place and they hold the foot-mats securely. None of the deposits heretofore secured by this dike are as yet jeopardized, nor will future results be appreciably influenced by the damage done to it.

The nature of the injuries indicate that they were made possible by the rotten cottonwood piles If the material had been newer or better the damage would have been much less. The first of these runs of ice carried away the corner of the Osceola No. 4 and Osceola-Bullerton dikes, which was repaired as above stated.

Early in the month of April, with the river at an overflow stage, Osceola Cross-dike No. 3 broke in three places. The large accumulation of drift held above No. 3 was liberated and went down the chute against No. 4. The latter broke shortly after at one place near the middle. The break in No. 4 again freed a large mass of drift, which went down Bullerton Chute and was received by Bullerton No. 2 without damage.

Soundings taken in the breaks showed no scour, and the fall of the river disclosed the significant fact that both dikes had given way by the piles breaking off at about the 20-foot stage of the river. The damage was confined to the upper part of the dikes. The lower parts remain intact and have thus far held the masses of sand-embedded drift in place and have prevented the deposits heretofore obtained in Osceola Chute from being scoured out.

The break in Osceola No. 4 has not materially enlarged, but the detached portions of No. 3 left by the three breaks have been gradually wrecked, until at present but a few fragments of that dike remain.

So far as present indications may be relied upon, the closure of this chute has not been jeopardized by the damage done to the dikes.

The manner in which all these dikes broke, as above described, shows conclusively that the failure was not due to any unusual pressure, error in location, or defect of original construction, but simply that the material of which they were built, cottonwood, had lived its life-time and could stand no longer. It is well known that other material can be obtained at but little increase of cost which has a life of four or five times that of cottonwood No dikes of standard construction have failed except from the weakening of the piles by decay, so it may be concluded that the life of the dike will be exactly that of the materials composing it. An evident corollary is, that, within reasonable limits of expense, none but the most durable woods should be used in their construction. A minor point also suggests itself, that since the decay is most rapid at the 20-foot stage, or thereabout, the life of a dike might be slightly prolonged by providing an intermediate support to the piles at about that elevation.

The work for bank protection has suffered but little damage. There has been a loss of about 500 feet of the middle section of the Fletcher's revetment, aside from which the entire line is in as perfect condition as when it was built. Considerable growths of willows have been secured on the upper portions, giving them even more resisting power than when new. The loss above mentioned is less than the most sanguine expectations of two years ago. It occurred only after the caving of the unprotected bank above and below had progressed so far that the ends of this isolated work were actually attacked from the rear. In fact the remarkable and wholly unexpected endurance of this work must cause some modification of the view previously held as to bank revetment, viz, that continuity is essential. It now seems fairly probable that banks of ordinary difficulty, if undertaken when *not rapidly* caving, can be effectually protected by discontinuous work, at a great saving of cost.

The effects of the works during the past year, though mainly conservative, have been beneficial.

The Gold Dust dikes were at last report so much out of repair that they were scarcely expected to hold the deposits already secured, much less to increase them. They have nevertheless induced deposits in the area controlled by them, but at an exceedingly slow rate. Nothing has occurred to modify the opinion, previously expressed, as to the inability of the dikes of this system to accomplish their ultimate purpose. But little increase of deposits can be detected in Osceola Chute. Bullerton Chute has filled at a fair rate above Cross-dike No. 1, less rapidly between No. 1 and No. 2, and very slowly and

with exceedingly soft material below the latter. The Plum Point dikes have secured extensive deposits both within and below them, though their efficiency has doubtless been impaired by the breaks in Nos. 5 and 6.

The revetments have secured a practical stability of bank lines from Gold Dust to the foot of Bullerton towhead, accompanied by an unprecedented stability of channel line and a corresponding excellence of channel. That this latter phenomenon is in some degree the effect of the former cannot be doubted.

Since my last report (November 30, 1885) no change of importance has occurred in the lines of the channel in the portion of the river under improvement. The channel early in the year divided on the small tow-head near the foot of Island 30, and as a consequence the shoalest water was to be found at that point. The tow-head was caving rapidly on both sides, and during the flood disappeared entirely. Latterly about the same water has been found at this point as on the Plum Point crossing below. This latter crossing is the one place on the reach where the river may be fairly said to be under control of the works, and its history is for that reason important.

Observations of depth and velocity in the various channels on the reach have been made at frequent intervals, and the results are appended in tabulated form. Especial attention is invited to the depths in the "Lower Plum Point crossing," which show that the low-water channel at that point did not fill up during any of the rises, a state of affairs, it may be safely asserted, which did not prevail at any shoal crossing on the river outside of the reaches under improvement. During all the rises culminating in a flood since this channel first opened, just a year ago, the river has not left it at any stage. The scouring effect of the high stages has been confined to the low-water channel, which, instead of filling up, as is the case in the unimproved river, has been left by each rise equally deep, and wider and straighter than it found it.

Shortly after taking charge of this district I began the preparation, for my own information and use, of a tabular exhibit of the results of all surveys made from the beginning of the work to the close of operations in January, 1885. This table, which was completed in midsummer of last year, was thought by a member of the commission to be of sufficient interest to be inserted in an annual report, and at his suggestion it is appended hereto. A complete explanation accompanies the table.

The following financial statement and general balance-sheet show the present condition of appropriations for this district:

Appropriation for improving Mississippi River (act of July 5, 1884).

FIRST DISTRICT.

Balance on hand November 30, 1885, as per last report, including estimated liabilities		$18,755 84
Expended from December 1, 1885, to June 30, 1886	$17,215 28	
Estimated liabilities to June 30, 1886	1,540 56	
		18,755 84

Improving Mississippi River, first district, Plum Point Reach.

Dr.				Cr.	
1885. Nov. 30	To liabilities To balance	$2,510 00 16,245 84	1886. June 30	By amount expended from Nov. 30, 1885, to date By estimated liabilities	$17,215 28 1,540 56
		18,755 84			18,755 84

A table of the present value of plant is appended.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

General Q. A. GILLMORE,
President Mississippi River Commission.

pproximate value of plant belonging to the United States and used upon the improvement of the Mississippi River.—First District.

Class of property.	No.	Approx. value, June 30, 1886.
eamer P. Kirns	1	$6 215
eamer Itasca	1	6 894
eamer Abbot	1	8 976
aunch Titania	1	899
ile-drivers	37	99,008
uarter boats	15	20,563
attress boats	10	22,318
raders	2	31,051
errick boats	3	4,447
arges	51	89,497
achine shop boat	1	4,242
Whitehall boats	7	196
kiffs	60	583
ools and appliances	....	8,000
ffice furniture	....	80
urveying instruments	....	200
Total value	....	248,259

Table showing comparative least channel-depths and velocities in various channels of the im proved portion of Plum Point Reach, Mississippi River.

Localities.		First group.						Second group.							
		Lower Plum Point Crossing.		Bullerton Channel.		Bullerton Chute.		Lynch's		Island 30 Channel.		Elmot Chute.		Island 3 Chute.	
Date.	Gauge.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.	Depth.	Velocity.
1885.															
Dec. 16	9.40	......	5.03	8.0	......	......	......	9.0	......	18.0	......	......	......	......	......
26	14.60	21.5	4.66	12.5	3.46	......	1.10	14.0	......	22.5	4.50	......	......	......	......
30	11.85	19.0	4.83	10.0	3.05	......	.77	10.0	......	19.5	4.41	......	......	......	......
1886.															
Jan. 2	11.00	19.5	4.66	9.0	3.38	......	.85	......	......	19.5	4.29	......	......	......	......
6	13.30	23.0	4.50	13.0	3.79	......	.98	16.0	......	22.0	3.96	......	3.46	......	......
20	16.40	23.0	4.21	15.0	3.67	......	1.23	......	......	24.0	4.62	......	......	......	......
28	18.40	25.5	4.79	18.0	4.04	......	1.89	......	......	25.5	4.75	......	......	......	3.5
Feb. 24	28.30	......	......	29.0	4.12	......	1.18	......	......	38.5	4.62	......	4.41	......	5.1
26	28.10	39.0	4.87	......	......	......	......	27.0	......	......	......	......	......	......	......
Mar. 3	25.00	35.0	4.62	21.0	4.21	......	1.10	......	......	34.0	5.12	......	4.00	......	4.4
6	22.70	......	......	25.0	4.00	......	1.10	24.0	......	32.0	5.32	......	......	......	......
12	17.70	27.0	4.62	19.0	3.63	......	.90	......	......	28.0	5.41	......	3.46	9.0	3.6
17	13.55	24.0	4.66	14.5	3.83	......	.73	12.5	......	23.0	4.79	......	3.67	......	2.6
23	12.35	19.0	4.83	13.5	3.87	......	.85	9.5	......	19.0	4.46	......	......	......	......
31	24.55	35.0	4.87	24.0	4.16	......	1.02	18.0	......	26.0	5.16	......	......	......	......
Apr. 5	28.90	33.0	......	30.0	......	......	......	29.0	......	33.0	......	......	......	15.0	......
9	30.85	35.0	4.75	33.0	3.75	......	1.39	18.0	......	34.5	5.65	......	4.75	......	5.4
15	32.75	......	......	31.0	3.63	......	1.56	......	......	......	......	......	......	......	......
16	32.90	......	......	......	......	......	......	......	......	......	......	......	......	......	4.7
20	33.30	40.0	4.91	......	......	......	......	......	......	......	......	......	......	......	......
25	33.10	37.0	4.83	27.5	4.00	......	2.22	......	......	......	......	......	......	......	......
28	32.35	36.5	4.95	......	......	......	1.93	......	......	......	4.91	......	4.83	......	4.2
May 3	24.50	30.0	4.95	25.5	3.50	......	1.18	24.5	......	33.0	4.79	......	3.88	......	3.7
6	18.80	27.0	5.08	21.0	3.71	......	.98	19.0	......	27.0	5.12	......	......	......	......
12	20.50	28.0	5.82	23.0	3.46	......	.98	......	......	29.5	4.17	......	4.91	......	3.7
15	23.75	31.0	5.28	24.5	3.46	......	1.60	24.0	......	30.0	4.75	......	4.04	......	4.7
19	27.00	......	......	27.0	4.08	......	1.39	......	......	......	......	......	......	......	......
22	27.40	33.0	5.61	30.0	3.71	......	1.68	28.0	......	34.0	4.66	......	4.41	......	5.0
26	25.50	33.0	5.12	27.0	3.79	......	1.56	27.0	......	32.0	4.91	......	5.03	......	4.8
28	22.85	30.0	4.91	23.0	3.54	......	1.43	22.0	......	29.5	4.70	......	4.17	11.5	3.6
June 1	19.20	28.0	5.33	20.0	3.34	......	.98	19.5	......	27.0	4.79	......	3.42	......	3.17
5	14.80	23.0	5.16	15.0	3.05	......	.73	15.0	......	23.0	4.99	......	3.79	......	2.39
9	12.80	20.0	......	14.0	......	......	......	12.0	......	20.0	......	......	......	......	......
11	12.20	19.0	......	14.0	......	......	......	13.0	......	21.0	......	......	......	......	......
16	18.40	22.0	5.70	17.0	2.92	......	.65	15.5	......	21.5	5.00	......	......	......	......
18	14.25	22.5	5.00	18.0	2.92	......	.65	16.0	......	20.0	4.91	......	3.17	......	1.72
23	16.50	21.5	5.45	17.0	3.04	......	.85	17.0	......	23.0	5.66	......	3.21	......	3.00
28	16.75	25.0	5.24	16.5	3.00	......	.77	17.5	......	22.5	5.24	......	3.17	......	3.46

NOTES.—The depths reported are the least found in the line of deepest water, or those which limited navigation for the time being. The velocities were measured on the same line and near the shoalest point. They were all taken with the current meter running at depth of 5 feet below the surface. They are individual velocities, taken to ascertain the relative draft of water in the different channels, and are useful for that purpose only. They have no relation to the average velocity or discharge.

The crossings forming group 1 of the table may be considered as competitors for the channel over Bullerton Bar. The third, Bullerton Chute, was completely closed by works; the second, Bullerton Channel, has remained partly obstructed by the diverting action of the works favoring the first channel, which latter has remained good by reason of carrying the water diverted from the other two.

The four channels of the second group are also competitors, of which the third and fourth have been restricted in discharge by the Gold Dust dikes, and the first by the directive action of the Fletcher's revetment. The second, Island 30, has carried the bulk of the water and has remained good.

Bullerton Area, Range 47–58.

Date.	Stage of river.	Location.	Mean smooth bottom. Referred to low water, 1879.	Mean smooth bottom. Above 10 ft. below low water, 1879.	Shoalest channel depth at prevailing stage. Feet.	Shoalest channel depth at prevailing stage. Location.
1881. Oct. and Nov.	23.8	Site of Plum Point dikes	−8.30	18.30		
		Site of Osceola dikes	.34	9.66		
		Open river	6.78	3.22	36.8	Range 50.
		Total area	.70	9.30		
1883. Jan. 11	6.0	Site of Plum Point dikes	−5.47	15.47		
		Site of Osceola dikes	9.99	.01		
		Open river	3.56	6.44	21.0	Between ranges 48 and 49
		Total area	2.70	7.30		
March 23	17.4	Site of Plum Point dikes	−5.69	15.69		
		Site of Osceola dikes	5.66	4.34	22.4	Break in O.-B. dike.
		Open river	3.40	6.60	21.0	Range 50.
		Total area	1.64	8.36		
Aug. 4 to 10	13.8	Site of Plum Point dikes	−4.33	14.33		
		Site of Osceola dikes	5.52	4.48		
		Open River	2.86	7.14	15.4	Range 49.
		Total area	1.59	8.41		
Aug. 27 to Sep. 3.	7.0	Site of Plum Point dikes	−4.60	14.60		
		Site of Osceola dikes	6.22	3.78		
		Open river	2.22	7.78	19.0	Range 49.
		Total area	1.29	8.71		
Oct. 15 to 23	4.4	Site of Plum Point dikes	−4.62	14.62		
		Site of Osceola dikes	5.45	4.55		
		Open river	3.34	6.66	20.0	Range 49.
		Total area	1.75	8.25		
1884. April 8 to 15	29.0	Site of Plum Point dikes	−5.79	15.79		
		Site of Osceola dikes	2.16	7.84		
		Open river	.94	9.06	31.0	Range 50–51.
		Total area	−0.39	10.39		
May 19 to 22	20.7	Site of Plum Point dikes	−4.01	14.01		
		Site of Osceola dikes	3.31	6.69		
		Open river	.66	9.34	21.7	Range 50–51.
		Total area	.53	9.47		
July 30 to Aug. 4	10.0	Site of Plum Point dikes	−5.97	15.97		
		Site of Osceola dikes	1.61	8.39	26.0	Break in O.-B. dike.
		Open river	3.98	6.02	11.0	Range 50-51.
		Total area	.95	9.05		
Sept. 9 to 13	4.9	Site of Plum Point dikes	−5.41	15.41		
		Site of Osceola dikes	2.49	7.51		
		Open river	3.98	6.02	13.0	Range 50–51.
		Total area	1.27	8.73		
Nov. 14 to 22	4.0	Site of Plum Point dikes	−5.67	15.67		
		Site of Osceola dikes	1.97	8.03		
		Open river	5.67	4.33	14.0	Range 50–51.
		Total area	1.91	8.09		
1885. Jan. 20 to 29	....	Site of Plum Point dikes	−7.40	17.40		
		Site of Osceola dikes	1.57	8.43		
		Open river	7.95	2.05	32.0	Range 51.
		Total area	2.83	7.17		

NOTES.—The figures preceded by a minus sign indicate elevations above a plane corresponding to low water of 1879.

"Mean smooth bottom" means the elevation of the bottom which would result if it were leveled up in such manner as to make the cuts equalize the fills. The areas remaining sensibly constant, this quantity is a good measure of the relative amount of scour or fill at any place at different epochs.

The site of Gold Dust and Plum Point dikes includes the whole area controlled by them, being all the bed of the river between the natural bank and the east line of the proposed regulated channel.

The site of Osceola dikes includes all areas between the natural bank and the west line of corrected channel.

"Open river" is the proposed corrected channel of 3,500 feet width

Gold Dust Area, Range 27–33.

Date.	Stage of river.	Location.	Mean smooth bottom. Referred to low water, 1879.	Mean smooth bottom. Above 10 ft. below low water, 1879.	Shoalest channel depth at prevailing stage. Feet	Shoalest channel depth at prevailing stage. Location.
1881. Oct. and Nov.	14.5	Site of Gold Dust Dike	−3.70	13.70		
		Open river	5.36	4.64	29.0	Foot Ashport Bar. Range 29.
		Total area	2.23	7.77		
1882. April 22 to 27	22.0	Site of Gold Dust Dike	−4.30	14.30		
		Open river	4.07	5.93	34.0	Range 28.
		Total area	0.82	9.18		
Dec. 18	3.3	Site of Gold Dust Dike	−4.29	14.29		
		Open river	6.88	3.12	16.0	Range 28.
		Total area	2.51	7.49		
1883. April 1	15.5	Site of Gold Dust Dike	−4.18	14.18		
		Open river	6.16	3.84	30.5	Range 28.
		Total area	2.23	7.77		
July 21 to 25	18.2	Site of Gold Dust Dike	−5.02	15.02		
		Open river	6.60	3.40	33.7	Range 29–30.
		Total area	1.97	8.03		
Sept. 19 to Oct. 8.	1.0	Site of Gold Dust Dike	−6.14	16.14		
		Open river	5.23	4.77	12.0	Range 28.
		Total area	.78	9.22		
1884. April 23	26.2	Site of Gold Dust Dike	−5.89	15.89		
		Open river	8.49	1.51	35.2	Range 29–30.
		Total area	2.57	7.43		
Sept. 22 to Oct. 1.	4.5	Site of Gold Dust Dike	−7.66	17.66		
		Open river	7.90	2.10	11.0	Range 28–29.
		Total area	1.64	8.36		

Craighead Point Area, Range 66–71.

Date.	Stage of river.	Location.	Mean smooth bottom. Referred to low water, 1879.	Mean smooth bottom. Above 10 ft. below low water, 1879.	Shoalest channel depth at prevailing stage. Feet.	Shoalest channel depth at prevailing stage. Location.
1881.						
Nov.	15.0	Total area	7.85	2.15	38.5	Range 70.
1883.						
Jan. 15	6.5	do	8.20	1.80	41.0	Range 66.
May 1	28.1	do	9.40	.60	53.6	Range 67.
Aug. 13	12.5	do	6.97	3.13	40.0	Range 67.
Oct. 25	5.3	do	6.97	3.13	31.3	Range 67.
1884.						
June 12	15.5	do	8.53	1.47	32.0	Range 67-68.
Nov 19	4.4	do	7.90	2.10	22.0	Range 68-69.

Ashport Bar-Island 30 *Area, Range* 27–42.

Date.	Stage of river.	Location.	Referred to low water, 1879.	Above 10 ft. below low water, 1879.	Feet.	Location.
1881.						
Oct. and Nov.	14.5	Site of Gold Dust Dike	−2.62	12.62		
		Open river	7.99	2.01	36.5	Range 37.
		Total area	3.57	6.43		
1882.						
April 27 to 30.	22.0	Site of Gold Dust Dike	−4.44	14.44		
		Open river	6.85	3.15	45.0	Range 39-40.
		Total area	2.15	7.85		
1884.						
Sept. 1 to Nov. 5.	8.5	Site of Gold Dust Dike	−6.14	16.14		
		Open river	7.72	2.28	18.0	Range 39.
		Total area	2.10	7.90		

Osceola Chute, Range 40–49.

Date.	Stage of river.	Location.	Referred to low water, 1879.	Above 10 ft. below low water, 1879.	Feet.	Location.
1881.						
Oct. and Nov.	14.5	Total area	−6.38	16.38		
1884.						
Nov. 1 to 5	8.5	do	−9.00	19.00		

APPENDIX F.

REPORT OF CAPTAIN SMITH S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE SECOND DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 30, 1886.

SIR: I have the honor to submit the following report upon the work of improving Mississippi River, second district, for the fiscal year ending June 30, 1886:

Aside from the ordinary care and necessary repairs of property and routine office duties, the only work done in the second district during the fiscal year has been the repair of the most serious fault in the Hopefield revetment and the reballasting with stone of some portions of that, and of the Memphis revetment, which were originally sunk with sacks of gravel. The work of repairing this fault, known as No. 4, the beginning of which was noted in my report of November 30, 1885, was completed in the early part of January, 1886. It comprised the complete renewal of the work for a distance of 1,140 feet, and the patching of a small break which occurred in October, 1885, immediately above the large one.

The general plan of work was identical with that heretofore followed, comprising a continuous hurdle mat 150 feet wide, sunk below low water, a continuous upper bank revetment extending from the water surface to the top of the bank, with the interme-

diate zone of varying width covered by "connecting mats," discontinuous in structure, but firmly joined to the upper work and to each other, and lapping well onto the subaqueous mat.

In construction especial attention was given to the internal strength of all the work, to secure junctions among the several parts, and with the old work above and below, and to anchoring to the bank both the subaqueous and shore revetments. As the defects in the present work in this locality have resulted mainly from a tendency of the upper revetment to slide down the bank, the latter point (anchorage) was especially considered, and with a view of increasing the range of this experiment, as also in the hope of greater security, anchor cables were run out from the old work below No. 4.

An experiment in drainage was contemplated, and directions given for the construction of a drain. The drain was begun at any early stage of the proceedings, but its completion was deferred until the river had risen several feet from the lowest stage. It was then hastily finished, but in such shape that it cannot fairly be credited with any good results which may follow, or charged with any bad ones.

No important changes were made in the methods of administration. The late date at which the work was authorized left no time for advertising, for which reason purchases of materials and supplies were made in open market, except the stone, which, not being required until near the close of operations, was obtained on requisition from the secretary of the committee on construction.

The 1,140 linear feet of bank in fault No. 4 were completely revetted at a total cost of $16.60 per foot. Several causes operated to increase this cost, among them the small amount of work to be done, the necessity of bringing plant from Plum Point and returning it; the serrated outline of the bank, requiring in the pockets nearly double the ordinary amount of shore work, and the fastenings to the old work above and below, which were tedious and expensive operations.

This revetment, for which $16.60 per foot of bank may be taken as a liberal estimate, needs only the addition of 25 feet width to the subaqueous mat (175 feet instead of 150 feet), to become what, in the light of present experience, I would recommend as a standard for localities of ordinary importance in this part of the river. The addition of 25 feet would mean an increase of 16⅔ per cent. in the cost of subaqueous work, which is now 49 per cent. of the whole. It seems safe, therefore, to estimate such work at $18 per foot for the future.

The reballasting required 3,000 yards of rock, of which 280 yards were placed in the Memphis revetment, immediately below Wolf River, and the remainder on the Hopefield work, below fault No. 4. A classified statement of expenditures for this work is herewith.

It was thought that with No. 4 repaired no apprehension need be felt for the safety of this work during the succeeding high water. This prediction has been fully verified, since all the rest of the work is to-day in practically the same condition as it was a year ago. The lowest fault near the end of the work has enlarged slightly, but has not caved back, and there has been a loss of a few feet at the extreme end, due to caving working up from below.

The Memphis revetment is in perfect condition; but its completion to the end of the paved levee is of the greatest importance.

The changes in the harbor of Memphis have been marked and beneficial. The corner of the sand-bar, which extended out from Hopefield Point, and around which the river made a very abrupt turn, has entirely cut away, as intimated in last report. The river now follows a more gradual curve, striking the Memphis front less squarely. The engorged section is now at the foot of Beale street. Memphis Harbor, above the Elevator, is now comparatively slack water, and some filling is taking place. These changes are entirely in the direction contemplated by the Commission when the plan for this improvement was adopted four years ago.

Two small breaks are reported to have occurred in the Long Lake Levee in this district during the last flood. No funds have been available for an examination of them.

The following financial statement and general balance-sheet show the present condition of appropriations for this district:

Appropriation for improving Mississippi River (act of July 5, 1884).

SECOND DISTRICT.

Balance on hand November 30, 1885, as per last report, including estimated liabilities		$29,787 93
Expended from December 1, 1885, to June 30, 1886	$22,760 97	
Estimated liabilities to June 30, 1886	1,772 39	
		24,533 36
Balance June 30, 1886		5,254 57

Improving Mississippi River, Second District, Memphis Reach and Harbor.

Dr.					Cr.
1885. Nov. 30	To liabilities	$6,388 57	1886. June 30	By amount expended from November 30, 1885, to date	$22,760 97
	To balance	23,399 36		By estimated liabilities	1,772 39
				By balance	5,254 57
		29,787 93			29,787 93

A table showing present value of plant is appended.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

General Q. A. GILLMORE,
President Mississippi River Commission.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, Second District.

Class of property.	No.	Approx. value, June 30, 1886.
Steamer H. M. Graham	1	$3,720
Launch Daphne	1	1,104
Flat-boats	3	745
Mattress-boats	2	6,624
Machine-shop boat	1	4,693
Screen-boats	4	3,312
Quarter-boats	4	5,013
Survey-boat	1	624
Barges	23	23,974
Skiffs	15	204
Pile drivers	9	22,890
Coal shells	2	331
Tools and appliances		4,000
Office furniture		120
Surveying instruments		150
Total value		77,504

Memphis Reach and Harbor. Statement of expenses for work done from November 1, 1885, to January 7, 1886.

Item.	Designation.	HOPEFIELD BEND. Administration.	General expense.		General repairs.	Revetment. Sub-aqueous mattress.		Upper-bank protection. Clearing bank.	Hydraulic grading.		Hand-grading.	Bank mattress.		Total upper-bank protection.		Total revetment.	
		Cost.	Amt.	Cost.	Cost.	Amt.	Cost.	Cost.	Amt.	Cost.	Cost.	Amt.	Cost.	Amt.	Cost.	Amt.	Cost.
Pay-roll		$473 00		$637 78	$136 00		$2,539 92	$60 37		$348 54	$208 73		$1,876 64		$1,994 28		$4,534 20
Subsistence:																	
Services		11 81		48 51	6 54		180 30	4 83		18 78	17 51		75 75		116 87		297 17
Stores		43 22		178 15	25 35		768 98	19 01		74 70	66 02		362 40		522 18		1,291 11
Brush	Cords					1,818	2,255 95					1,114	1,371 55	1,114	1,371 55	2,932	3,627 50
Poles	Cords					171½	291 17					80	135 83	80	135 83	251½	427 00
Stone	Cu. yds					1,620	1,620 00					882	882 00	882	882 00	2,502	2,502 00
Iron	Lbs					8,640	393 76					1,822	57 43	1,822	57 43	10,462	351 19
Wire	Lbs					24,310	924 51					11,260	435 42	11,260	435 42	35,570	1,359 93
Wire rope	Feet					4,825	205 06									4,825	205 06
Spikes and nails	Lbs					5,150	165 20					2,350	64 80	2,350	64 80	7,500	230 00
Coal	Bush		217½	21 75					892½	89 25				892½	89 25	892½	89 25
Hire of tugs				37 50			35 00										35 00
Miscellaneous				71 78	74 12					1 75					1 75		1 75
Totals		528 03		995 47	242 01		9,279 85	84 21		533 02	292 26		4,761 82		5,671 31		14,951 16
Percentage of cost		2.79		5.27	1.28		49.00	0.45		2.82	1.54		25.15		29.96		78.95
Work done						1,628 squares continuous mattress. 1,185 squares connecting mattress. 2,408 squares bank covered.			1,140 linear feet. 12,201 cubic yds.		1,764 cubic yds.	800 squares covered.		800 squares.			
Cost per unit						$3.85 per square covered			$0.0453 per cubic yard.		$0.1657 per cubic yd.	$5.95 per square covered.		$7.00 per square covered.			
									Total cost of grading, $825.28, or $0.724 per linear foot, or $0.0501 per cubic yard.								

Memphis Reach and Harbor. Statement of expenses for work done from November 1, 1885, to January 7, 1886—Continued.

Item.	Designation.	HOPEFIELD BEND—continued.					Memphis Harbor, ballasting shore work.		Salvage work on sunken barge.	Hopefield Bend, ballasting old revetment.		Grand total.	
		Steamer H. M. Graham.		Total, Hopefield Bend.		Per cent of cost.							
		Amount.	Cost.	Amount.	Cost.		Amount.	Cost.	Cost.	Amount.	Cost.	Amount.	Cost.
Pay-roll	....	....	$1,046 84	....	$6,827 82	36.07	....	$57 68	$231 50	....	$355 00	....	$7,472 00
Subsistence:													
Services	....	....	142 84	....	506 87	2.68	....	....	12 38	....	42 75	....	562 00
Stores	....	....	160 78	....	1,704 61	9.00	....	....	60 83	....	121 39	....	1,886 83
Brush	Cords	....	....	2,932	3,627 50	19.16	....	....	....	....	....	2,932	3,627 50
Poles	Cords	....	....	251½	427 00	2.25	....	....	....	....	....	251½	427 00
Stone	Cu. yards	....	....	2,502	2,502 00	13.22	280	280 00	....	974	974 00	3,756	3,756 00
Iron	Pounds	....	....	10,402	351 19	1.85	....	....	....	....	....	10,462	351 19
Wire	Pounds	....	....	35,570	1,359 93	7.18	....	....	....	1,650	451 44	47,220	1,811 37
Wire rope	Feet	....	....	4,825	205 06	1.08	....	....	....	....	....	4,825	205 06
Spikes and nails	Pounds	....	....	7,500	230 00	1.22	....	....	....	....	....	7,500	230 00
Coal	Bushels	7,275	750 25	8,385	861 25	4.56	....	....	....	....	....	8,385	861 25
Hire of tugs	....	....	....	....	72 50	0.38	....	....	20 00	....	....	....	92 50
Miscellaneous	....	....	108 95	....	256 60	1.35	....	....	84 00	....	....	....	310 00
Total	....	....	2,215 66	....	18,932 33	100.00	....	337 68	408 71	....	1,944 58	....	21,623 30
Percentage of cost	....	....	11.71	....	100.00								
		Work done		3,613 squares built. 3,208 squares covered.									
		Cost per unit		$5.90 per sq. covered.									

NOTE.—*Administration* includes services of assistant engineer and clerical force.
General expense includes watching and caring for fleet, property, and supplies, coaling steamboats, and all other unitemized expenses.
General repairs includes all repairs to plant and property.

APPENDIX G.

REPORT OF CAPTAIN WILLIAM T. ROSSELL, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 26, 1886.

COLONEL: I have the honor to inclose herewith report on third district, Improving Mississippi River, for the fiscal year ending June 30, 1886.

Very respectfully, your obedient servant,

WM. T. ROSSELL,
Captain of Engineers.

Col. Q. A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

REPORT.

During the past fiscal year the third district, Improving Mississippi River, was in charge of Capt. Clinton B. Sears, Corps of Engineers, until May 14, 1886. On this day he was relieved by Capt. William T. Rossell, Corps of Engineers, by virtue of S. O. No. 89, Par. 2, Headquarters of the Army A. G. O., Washington, April 16, 1886.

I.—LAKE PROVIDENCE REACH.

This reach is thus described. It extends from Carolina Landing, 517 miles below Cairo, to the foot of island No. 95, a distance of 35 miles.

For an account of the physical character of this reach the proposed improvement and work done previous to June 30, 1885, reference should be made to the reports of the Mississippi River Commisson for past years.

During the fiscal year ending June 30, 1886, all the work done, except care of public property, has been repairs to the Balcshed system of dikes and the building of an additional dike across the chute on range 66, the whole work consisting in closing the gaps left in Stack Island cross dike and in dike No. 11 the previous season; building a new dike across the chute on range 66, and extending the dike on range 69 across the chute to the bar on the Mississippi shore.

Dike No. 10, on range 66, was constructed of four rows of piles securely braced, with a heavy footmat sunk between the rows of piling. Dikes 11 and 13, on ranges 67 and 69, were of two rows of piles braced, but without footmat.

The repairs to the Stack Island cross-dike were made by re-enforcing the ends with three rows of piles and driving three rows across the gap in front of the dike, the whole well braced and a heavy footmat sunk across the gap.

These repairs were begun November 17, 1885, and finished January 11, 1886. The amount of the allotment was $13,500, and the amount expended $12,881.34. The small amount of work done was due entirely to lack of funds. The methods used were those heretofore described.

CONDITION OF WORKS.

Duncansby system of dikes.—This system has nearly disappeared, only portions of cross dikes 6, 7, and 8 remaining. They have, however, served the purpose for which they were constructed, viz: reducing the volume of water through Skipwith chute, and thereby preventing its enlargement. The contraction has caused an increase of channel depth here.

Cottonwood system of dikes.—This system remained in good condition until April, 1886. Early in this month the longitudinal dike was broken by a raft or barge, and these breaks have since enlarged, and about 300 feet of cross dike No. 3 has washed away.

This system has caused the bar below to increase both in length and height, concentrating the water and fixing the channel near Mayersville Island.

Mayersville system of dikes.—During the last high water a large amount of drift collected in front of the Mayersville cross-dike, and finally broke the piles at about the 20-foot stage. There remain, however, large quantities of drift embedded in the sand in front of the dike and extending across the chute.

The Mayersville system of dikes has caused a general shoaling the entire length of the chute.

Baleshed system of dikes.—The gap in the main dike between range 64 and range 66 has increased about 500 feet, due to the breaking of the piles during the last high water. The drift lodged in front of Stack Island. The cross-dikes 10, 11, and 13 were successively broken by the drift during the high water. This system of dikes, together with the Stack Island dikes, have perfectly served their purpose, changing the channel from behind the island and preserving a good, navigable channel at this place.

Stack Island system of dikes.—This system is in good condition, and has suffered no damage. Its admirable effect is seen in the filling up of the chute behind the island.

Pilcher's Point revetment.—This revetment was never finished, but a portion of the caving bank slipped, and in the report for 1885 it was estimated that 30 per cent. of the revetment work had disappeared. These breaks, or slips, took place at irregular intervals, and were of varying sizes. During the past year gradual slipping has taken place, and but a small portion of the revetment work can be seen in place—probably about 25 per cent. This is in small and detached pieces of 300 feet in length down, except at the upper end where about 1,500 feet is still in place.

In spite of this apparent loss, the result obtained has been satisfactory. Where the revetment was built the bank, in its general line, is very nearly where it was at the completion of the work.

Mayersville Island revetment.—The head of this island has continued to cut away under the direct action of the current until it is now opposite the Mayersville cross-dike. Nearly the entire revetment has been washed away. I cannot state that any result whatever is directly attributable to the Mayersville Island revetment.

FINANCIAL STATEMENT.

Lake Providence Reach.

Available balance June 30, 1885		$22,070 45
Received from sale of fuel, and deposits		83 75
Transferred from Yazoo Front		144 17
Transferred from general service		29,215 04
Total		51,513 41
Expended during year	$43,516 56	
Transferred to levees, Tensas Front	2,000 00	
		45,516 56
Balance June 30, 1886		5,996 85
Expended:		
For services		30,054 79
Material, supplies, and outfit		3,528 47
Subsistence		2,808 82
Plant and repairs to same		178 55
Fuel		2,355 38
Retained percentage paid on previous contract deliveries for material	194 11	
Retained percentage paid on previous contract deliveries for subsistence	1,458 10	
		1,652 21
Miscellaneous—Includes office expenses (except services) mileage, telegrams, medicines and medical services, transportation and traveling expenses		2,938 34
Total		43,516 56

The original condition of the channel along this reach was bad. The channel was flat, badly defined, and often, in extreme low water, only five feet deep. The original project for improvement was the narrowing of the water way to 3,000 feet by closing the chutes and creating artificial banks through depositions, and the preservation of the natural curves of the river by revetting the caving banks. No important changes have been made in the general plan.

To June 30, 1886, the total amount expended on the reach was $2,217,643.67. The results are shown in the table inclosed, giving depths of water over the three shallow crossings of the reach for 1884, '85, and '86. Previous to work the depths found were often as little as 5 feet.

The least depths in 1884:

	Feet.
Stack Island Crossing, Aug. 30	10
Ben Lomond Crossing, September 20 and 30	11
Least depths in 1885:	
Duncansby Crossing, Oct. 20 and 30	16
Stack Island, July 30, Aug. 10, Oct. 10 and 20	14
Ben Lomond Crossing, Oct. 30	13

The low water stage of 1886 has not yet been reached, and up to the present no less depth than 20 feet has been found on any of the crossings. The results then show that the improvement on this reach has been successful.

During the past fiscal year the extreme oscillation has been 32.37 feet. Lowest water, October 26, 1885, 5.54, Lake Providence gauge; highest water, May 7, 1886, 37.91, Lake Providence gauge.

II.—VICKSBURG HARBOR.

The work here consists of the improvement of the harbor proper (Centennial Lake, in front of the town), and the maintenance of Delta Point, opposite Vicksburg. The former is entirely local in character, and would add nothing to the general improvement of the river.

An examination of the basin dredged in front of the city of Vicksburg, and the canal leading thereto, was made in January, 1886, by Assistant Engineer Coppée. It was found that the average level of the bottom of the basin was plus 5 feet of the gauge for a width of about 300 feet, and in the canal plus 7½ feet. The basin was dredged in 1883 to the zero of the gauge for a width of 160 feet, and to plus 5 feet of the gauge for a width of 160 feet. The canal was dredged to the zero of the gauge for a width of 80 feet.

Examination shows, then, that the average fill in the basin to January, 1886, was only 2½ feet, and in the canal 7½ feet. Dredging the basin may be regarded as permanent, or as requiring work only at long intervals, but to keep the canal open will require yearly work.

The holding of Delta Point is deemed essential to prevent further recession of the river from Vicksburg and to maintain the regimen of the river immediately below. This has been held by mattress and riprap revetment for nearly four years. During the past year no work whatever has been done, and the revetment has fulfilled its purpose well. One small break in the upper revetment was reported on July 3, 1886, but is in no way dangerous.

The total amount spent on Vicksburg Harbor up to June 30, 1886, was $373,894.41. Of this, $203,229.87 was spent prior to the creation of the Mississippi River Commission, and under the Commission $170,664.54 has been spent.

FINANCIAL STATEMENT.

Vicksburg Harbor (Delta Point).

Available balance, June 30, 1885	$3,682 88
Transferred from general service	250 00
Total	3,932 88
Expended	3,872 29
Balance, pledged	60 59
Expended:	
For services	1,151 23
For material, supplies, and subsistence*	2,552 44
Miscellaneous (includes mileage, traveling expenses, and telegrams)	168 62
Total	3,872 29

LEVEES.

No work has been done on levees during the past fiscal year.

Yazoo Front.—The levees heretofore constructed, those by the Government, and by other means, have been kept up and in good repair by the State authorities, and during the past high water controlled the flood, no breaks occurring.

*This amount was the total of bills of supplies, &c., indebtedness of Lake Providence Reach, to offset material, supplies, and subsistence stores furnished from Lake Providence surplus stores for the work at Delta Point.

Tensas Front.—This system of levees in the third district extends from Cypress Bayou, Arkansas, to opposite Warrenton, Miss.

The levees in Louisiana remain intact, and held the flood in the past high water; but in Arkansas numerous breaks took place, notably from Cypress Creek to Arkansas City.

FINANCIAL STATEMENTS.

Levees—Tensas Front.

Available June 30, 1885		$32 26
Transferred from Lake Providence		2,000 00
Total		2,032 26
Expended		32 26
Balance June 30, 1886		2,000 00
Expended—		
Retained percentage	$3 82	
For mileage	28 44	
		32 26

Levees—Yazoo Front.

Available June 30, 1885		$174 55
Expended	$30 38	
Transferred to Lake Providence	144 17	
		174 55
Balance		0 00
Expended—		
Retained percentage	$3 50	
For mileage	26 88	
		30 38

In conclusion I would respectfully call attention to the report of Assistant Engineer Arthur Hider, in local charge at Lake Providence Reach, appended.

My thanks are due to the assistant engineers and others on the work for the energy, zeal, and intelligence which they have shown.

Respectfully submitted.

WM. T. ROSSELL,
Captain of Engineers.

REPORT OF ASSISTANT ENGINEER HIDER.

WILSON'S POINT, LA., *July* 15, 1886.

SIR: The following report of operations for the fiscal year ending June 30, 1886, is respectfully submitted.

No construction work has been done during the year, except repairing the gaps in cross-dikes in the lower end of Baleshed Chute and the building of an additional dike across the chute on range 66. This work was done for the purpose of preventing the threatened widening of the chute at its lower end, and to counteract the tendency of the river to again make a channel behind Stack Island.

The work consisted in closing the gaps left in Stack Island cross-dike, and in dike No. 11, the previous season; building a new dike across the chute on range 66, and extending the dike on range 69 across the chute to the bar on the Mississippi shore.

Dike No. 10, on range 66, was constructed of four rows of piles securely braced, with a heavy footmat sunk between the rows of piling. Dikes Nos. 11 and 13, on ranges 67 and 69, were of two rows of piles braced, without footmat; the repairs to the Stack Island dike were made by re-enforcing the ends with three rows of piles, and driving three rows across the gap in front of the dike; the whole well braced, and a heavy footmat sunk across the gap. These repairs were begun November 17, 1885, and finished January 11, 1886.

The amount of the allotment was $13,500; the amount expended, $12,881.31.

PRESENT CONDITION OF CONSTRUCTION WORK.

Duncansby system of dikes.—These dikes have been carried away by the caving of the bar on which they were constructed; there are now standing portions only of cross-dikes 6.

7, and 8; the parts remaining are next the Mississippi shore, extending out from the bank about 800 feet.

Cottonwood system of dikes.—Breaks have occurred in the main dike above and below cross-dike No. 3, 400 and 300 feet in length respectively. The outer end of this cross-dike has also washed away for a length of 300 feet.

Mayersville system of dikes.—The large amount of drift which accumulated in front of this dike during the high water broke the dike, carrying with it the loose drift and breaking off the piling at a little above the 20-foot stage. There remain in front of the dike, extending across the chute, large quantities of drift embedded in the sand, which practically forms a sill.

The rapid caving off of the head of the island, however, will soon allow an entrance to the chute below the dike, and the dike itself will have little effect in filling up the chute.

Baleshed system of dikes.—The gap in the main dikes between ranges 64 and 66 since the last report has increased in length from 1,000 to 1,500 feet by the breaking off of the piles during the last high water. The entrance to the chute at this point has shoaled materially.

During the high water a large quantity of drift lodged against the upper of the cross-dikes built during the low-water season—dike No. 10. In February the dike gave way, the *débris* breaking through cross-dikes Nos. 11 and 13, and lodging in front of the Stack Island cross-dike; the width of the breaks through these dikes is about 400 feet. In other portions of the system there have been no breaks of importance.

The piles, which are of cottonwood, are rotting rapidly where exposed, and unless extensive repairs are made before the next high water season serious damage may be expected.

Stack Island System of Dikes.—The Stack Island dikes seem to have suffered no damage; the main cross-dike has large quantities of drift lodged in front of it, and is having a good effect in filling up the chute behind Stack Island.

Pilcher's Point Revetment.—There has been a gradual slipping in of the bank revetment during the year from time to time, until, except at the upper end, where about 1,500 feet of it is still intact, not more than 10 per cent. of the bank formerly revetted remains with the revetment in place, and this is distributed at irregular intervals in lengths of 300 feet and less.

Mayersville Island Revetment.—The head of the island has been gradually caving back until it is now opposite the Mayersville cross-dike. The face of the island has caved behind the revetment, destroying all the work done, except about 1,800 feet at the extreme lower end of the Island.

GENERAL EFFECT OF THE CONSTRUCTION WORKS.

The revetment constructed above Pilcher's Point has had the effect of preventing any further recession of the bend. The caving has practically ceased, and the shore line is about where it was when the revetment work was completed.

The Duncansby dikes may be considered to have served the purpose for which they were designed, reducing the volume of water formerly passing through Skipwith's Chute, and thereby preventing its enlargement. The consequent concentration of the water on the outside of the towhead has had the effect of improving the channel at this locality.

The Cottonwood dikes have caused the bar below to increase both in length and height, thereby concentrating the water along the outside of Mayersville Island, fixing the channel contiguous to the island.

The effect of the dikes in Mayersville chute has been to cause a general shoaling the entire length of the chute.

The Mayersville Island revetment has not been successful in preventing the caving back of the face of the island.

The Baleshed dikes have been the means of changing the river channel from behind Stack Island, and of maintaining a good channel in this part of the reach.

The effect of the Stack Island dikes is shown by the filling up of the chute behind Stack Island.

CHANNEL DEPTHS.

The general location of the low water channel through the reach is the same as last season, except the usual movement of the crossings from year to year down stream.

There has been an ample channel depth for all the requirements of navigation over the three shallow crossings and through the entire length of the reach; no difficulty on account of lack of water has been experienced.

The least depths during the low-water season of 1884 were, on Stack Island crossing,

10 feet; Ben Lomond crossing, 11 feet. During the low-water season of 1885 the least depths found on the same crossings were 14 and 13 feet respectively.

The lowest reading of the Lake Providence gauge was, October 26, 1885, 5.54 feet; the highest on May 7, 1886, 37.91 feet; a range of 32.37 feet between extreme high and extreme low water.

The least depths found during the low-water seasons of 1884 and 1885, also during the high-water of 1886, on the shallow crossings are given in the statement below.

Statement showing least channel depths, Lake Providence Reach, 1884–'85–'86.

	1884.			1885.				1886.			
	L. P. gauge reading.	Stack Island crossing.	Ben Lomond crossing.	L. P. gauge reading.	Duncansby crossing.	Stack Island crossing.	Ben Lomond crossing.	L. P. gauge reading.	Duncansby crossing.	Stack Island crossing.	Ben Lomond crossing.
Jan. 10	30.0			29.4		40.0	39.0	17.8	27.0	24.0	24.0
Jan. 20	25.4			83.6		46.0	43.0	22.5	82.0	81.0	27.0
Jan. 30	25.5			34.6		44.0	42.0	21.5	81.0	29.0	32.0
Feb. 10	30.0			31.4		39.0	38.5	20.5	27.0	27.0	20.5
Feb. 20	36.9			27.1		83.0	33.0	27.5	85.0	83.0	27.5
Feb. 28	37.7			21.2		24.5	26.5	81.7	88.0	32.0	81.7
Mar. 10	38.1			18.6		23.5	26.0	82.0	42.0	29.0	38.0
Mar. 20	38.1			27.1				25.0	30.0	27.0	84.0
Mar. 30	37.8			27.0				22.5	33.0	27.0	85.0
Apr. 10	36.6			22.0				32.8	40.0	36.0	32.3
Apr. 20	36.8			28.1				35.5	41.0	39.0	35.5
Apr. 30	36.5			32.2				87.5	43.0	38.0	85.8
May 10	36.5			85.5				37.5	45.0	40.0	48.0
May 20	35.9			29.4				85.5	43.0	88.0	44.0
May 30	32.5			22.9				35.2	39.0	37.0	42.0
June 10	24.6			25.0	81.5	24.0	82.5	27.0	81.0	28.0	32.0
June 20	25.3			24.5	81.0	21.0	29.5	21.0	28.0	21.0	29.0
June 30	25.7			28.0	85.0	22.5	29.5	23.0	82.0	25.0	82.0
July 10	21.1			24.7	31.4	20.0	24.0				
July 20	19.6			22.0	29.0	17.0	26.0				
July 30	15.8			15.5	20.0	14.0	18.5				
Aug. 10	15.5	18.0	24.0	14.0	19.0	14.0	21.0				
Aug. 20	12.6	14.0	12.0	15.6	36.0	15.0	28.0				
Aug. 30	8.9	10.0	14.0	12.3	30.0	15.0	29.0				
Sept. 10	9.1	14.0	17.0	13.4	32.0	16.0	30.0				
Sept. 20	6.6	17.0	11.0	18.0	35.0	19.0	25.0				
Sept. 30	5.8	15.0	11.0	15.5	30.0	22.0	20.0				
Oct. 10	14.8	24.5	15.0	9.0	22.0	14.0	15.0				
Oct. 20	13.7	26.0	24.0	7.1	18.0	14.0	13.0				
Oct. 30	12.0	24.5	22.5	8.0	18.0	15.0	14.0				
Nov. 10	11.1	23.0	26.0	10.8	20.0	16.0	15.0				
Nov. 20	7.25	21.0	17.0	19.3	34.0	28.0	26.0				
Nov. 30	6.58	19.0	16.0	13.5	23.0	19.0	19.0				
Dec. 10	7.83	20.0	18.0	10.5	21.0	18.0	18.0				
Dec. 20	11.0	23.5	19.0	12.0	22.0	21.0	19.0				
Dec. 30	12.0	21.0	20.0	16.5	25.0	24.0	24.0				

NOTE.—No soundings were taken on the crossings from January to August, 1884, or from March to June, 1885, the river being at mid stage.

From comparison of the special surveys of December 3, 1884, March 3, and December 17, 1885, made in the bend above Pilcher's Point to determine the condition of the revetment work there constructed, it would seem that in this locality the mattress built failed to protect the bottom from the eroding action of the current. Seven of the eleven sections show a scour of varying depth; on one section the scour is 80 feet deep. On the other four sections the bottom has filled in over the mat in places 25 feet deep. From an examination of some of the sections, an increase in the width of mats so as to extend out to the deepest water would suggest itself as the proper way to meet this difficulty. On other sections the indications are such that it is uncertain whether such increase of width would accomplish the desired result.

The destruction of the upper bank revetment in many places has evidently been due to the current acting under the revetment where not of sufficient thickness, or else that slips or caves above allowed the water to find its way under the revetment and to erode the light material of which the bank is composed, gradually undermining and steepening the slope, until the support of the revetment was removed, and it slipped bodily in

In other cases the destruction of the revetment seems to be due to sinking down suddenly of portions of the bank. This can be accounted for by the fact of the water saturating the fine sand which is frequently found in layers distributed in the bank. The dry sand is thus transformed into a semi-fluid state in the nature of quicksand, and a fall taking place in the river the sand flows out, leaving a void under the bank. This causes a settlement of the bank and the destruction of the revetment.

Where banks are to be reveted, and the material of which they are composed is of sand or other similar material, experience seems to demand a thicker and wider mat, and a revetment more closely laid than has been the practice heretofore, to insure satisfactory results.

In dike work where, on account of their height, the cottonwood piles have been exposed during successive low-water seasons, the piles, braces, and longitudinal stringers have rotted to such an extent as to reduce their strength, so that they have but little stability. The life of cottonwood, when thus exposed to the alternate action of the water and air, is of short duration. The change to cypress timber for the construction of dikes where practicable, and dikes of increased strength in localities where drift in large quantities is to be encountered, is recommended.

In fact, stronger constructions, both of revetment and dike work, are believed to be necessary to insure stability. The experiences of the last two seasons all point in this direction.

CAVING BANKS.

Below are the localities where the greatest amount of caving has taken place during the year.

Right bank.—For a distance of two miles below Pilcher's Point, in the vicinity of Elton Plantation, and at Judge Montgomery's.

Left bank.—At Williams' Plantation, the head of Mayersville Island, and in the vicinity of Ben Lomond.

The amount of caving of the banks from range 14 to range 100, a length of channel of 28.371 miles, for a period of nearly three years, is shown in the statement below. The original shore-line survey of November, 1881, has been compared with that of October, 1884, and measurements taken at intervals of 1,000 feet on both sides of the river. The mean of all the measurements thus obtained for each section of the river compared has been entered in the tabular statement as the average width of the caving for that particular section.

Statement showing average bank recession from November, 1881, to October, 1884; Lake Providence Reach.

Section of river.	Distances.		Average width of caving.				Mean annual caving.		Section.
	R. bank.	L. bank.	R. bank.	Number of measurements.	L. bank.	Number of measurements.	R. bank.	L. bank.	
	Feet.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*	
R. 14 to R. 30	32,600	25,600	88.0	31	86.3	23	30.2	29.5	1
R. 30 to R. 50	33,400	40,200	51.6	30	143.7	41	17.6	49.2	2
R. 50 to △ Arlington	51,700	46,000	84.6	49	89.1	48	29.0	30.5	3
△ Arlington to R. 100	41,300	27,000	179.9	43	124.2	27	61.7	42.6	4

Length of shore-line compared, right bank 30.1 miles; left bank 26.2 miles; channel length 28.371 miles.

	Feet.
Mean yearly distance bank recession right bank, 153 measurements	91.2
Mean yearly distance bank recession left bank, 139 measurements	38.2
Average yearly increase of width of river between high-water main shore lines	129.4
	Acres.
Average yearly rate of caving	416.9
Average yearly rate for each channel mile	14.7

Amount expended for labor and subsistence.

Classification.	Pay-roll.	Subsistence.	Total.
Care of fleet and property	$20,276 29	$3,636 17	$23,912 46
Repairs to dikes in Baleshed Chute	6,441 58	1,506 13	7,947 71
Total	26,717 87	5,142 30	31,860 17

The maximum number of men employed in any one month was 150; the minimum 35.

Cost of raw material, each ration	$0.265
Cost of each ration served	0.381
Cost of each ration for each day's labor served	0.410

Work done.

Footmat built and sunk	squares	460.18
Brush cut and loaded	cords	481.3
Poles cut and loaded	do	76
Rock loaded	cubic yards	381
Piles driven	number	978
Stringers put on	do	381
Braces put on	do	786
Braces, diagonal	number	48
Barges calked	do	10
Boats (quarter) calked	do	2
Pile-drivers calked	do	8
Skiffs repaired and calked	do	7
Pile-driver engines fitted up	do	7

Boiler changed on Meter, and outside painted; Vidalia painted and other repairs; minor repairs made to boats and machinery.

Material expended.

Stone	cubic yards	521
Poles	cords	76
Piles	number	978
Stringers	do	381
Braces	do	786
Braces, diagonal	do	48
Wire	pounds	14,939
Spikes	do	9,971
Coal	bushels	10,394½
Lumber, B. M.	feet	3,295
Gas pipe	do	297
Iron	pounds	635
Oakum	do	4,081
Brass	do	8
Babbitt metal	do	24
White lead	do	500

Appproximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, third district.

Class of property.	Approximate value, June 30, 1886.	Class of property.	Approximate value, June 30, 1886.
Steamer Osceola (tow-boat)	$17,500	1 carpenter-shop boat	$2,700
Steamer Vidalia (tow-boat)	15,000	1 floating dry-dock (with machinery)	3,000
Steamer Emma Etheridge (tow-boat)	11,600	1 end-dock, 37 by 16	100
Steamer Meter (survey boat)	6,000	1 end-dock, 27 by 8	50
2 hydraulic graders	30,000	1 wharf-boat	800
1 hydraulic grader (old)	800	1 derrick-boat	800
2 mattress-boats, 200 by 30	5,400	1 pump-boat (with machinery)	800
4 mattress-boats, 160 by 30	9,000	45 barges, decked and scow built	57,000
1 mattress-boat, 149 by 49 (old)	800	11 barges, model	36,000
4 screen-boats	3,600	16 pile-drivers (with machinery)	44,000
1 quarter-boat, 185 by 30 (with outfit)	3,250	1 catamaran	75
10 quarter-boats, 130 by 25 (with outfit)	25,000	10 calking-flats	100
1 quarter-boat, 100 by 30 (with outfit)	1,800	7 yawls	400
2 quarter-boats, 100 by 25 (with outfit)	2,500	59 skiffs	400
2 quarter-boats, 80 by 20 (with outfit)	1,800	18 coal-barges and boats (old)	3,000
1 quarter-boat, 70 by 18 (with outfit)	400	Tools and appliances	3,700
1 machine-shop boat (old)	250	Office furniture (including drawing instruments)	730
1 machine-shop boat (with outfit of machinery)	4,500	Surveying instruments	2,000
		Total	294,355

APPENDIX H.

REPORT OF MAJOR C. W. RAYMOND, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New York, July 20, 1886.

COLONEL: I have the honor to transmit herewith my annual report of operations for year ending June 30, 1886, for works under my charge in fourth district, for improving Mississippi River.

The charge of this district was transferred to me by Major Amos Stickney, Corps of Engineers, February 27, 1886.

Very respectfully, your obedient servant,

CHAS. W. RAYMOND,
Major of Engineers.

Col. Q. A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

IMPROVEMENT OF THE HARBOR OF NEW ORLEANS, LOUISIANA.

The adopted projects for work in New Orleans Harbor are, first, to cover the caving bank in the Carrollton Bend for a distance of about 10,000 linear feet, with a mattress of willow brush ballasted with stone; second, to protect the portion of bank known as Gouldsboro' Bend, about 5,000 linear feet, by means of sloping submerged spurs, made mostly of brush and stone and placed at intervals which are as yet experimental, varying from 500 to 1,600 feet.

The total amount expended on the above projects to June 30, 1885, is $146,047.02.

A small portion of the brush mattress has been laid in the Carrollton Bend. Two spurs have been completed, and the foundation mattress and two cribs of a third placed in the Gouldsboro' Bend.

A valuable plant for the work has been acquired, and nearly all the stone for ballast, iron rods, and other material, except brush, for the completion of the six spurs in the Gouldsboro' Bend is on hand.

Owing to lack of funds no work has been done during the fiscal year except care of property, and a survey to determine the effect and condition of the submerged spurs constructed in the previous year.

The survey was made in November and December, 1885, and developed the fact that the 100-foot contour had been thrown out from the bank. The other contours, while not so much changed in position, had become more regular.

No caving of the bank or damage to the spurs could be discovered by inspection or inquiry.

The gentle slope of the top of the spurs from the bottom at river end to low-water surface at shore end, thus avoiding any abrupt change of cross-section of water-way, appears to have accomplished the hoped-for result of deflecting the current from the bank without causing any great scour at river end of spur or violent eddy below.

While the results appear favorable to this method of bank protection, a longer time must of course elapse before the test can be considered satisfactory.

The revised estimated additional amount needed for completion of work in New Orleans harbor is as follows:

Carrollton Bend (mattress project)	$158,600
Gouldsboro' Bend (completion), spurs	35,000
Gretna Bend, spurs	64,200
Bend above Gretna to a point nearly opposite City Park, right bank, spurs	396,600
Total	654,400

The amount that can be profitably expended during the fiscal year ending June 30, 1888, is $100,000.

The work is in the collection district of New Orleans.

The nearest light-house is at the mouth of the Mississippi River.

The total exports of merchandise for the fiscal year ending June 30, 1886, was $82,303,520.93.

FINANCIAL STATEMENT.

Improving Mississippi River (no limit)—Harbor at New Orleans.

July 1, 1885, balance on hand	$596 57
Sept. 7, 1885, amount allotted	4,000 00
Nov. 13, 1885, amount allotted	162 86
Nov. 16, 1885, amount allotted	1,400 00
	6,159 43
July 1, 1886, amount expended during fiscal year, exclusive of outstanding liabilities, July 1, 1885	4,151 78
July 1, 1886, balance on hand	2,007 65

CUSTOM-HOUSE, NEW ORLEANS, LA.,
Collector's Office, July 12, 1886.

SIR: The following statistics relative to the commerce of this port are furnished in compliance with the request contained in your letter of the 16th ultimo:

Entrances and clearances of vessels, coastwise and foreign, from July 1, 1885, to June 30, 1886, inclusive.

	Entrances.		Clearances.	
	No.	Tonnage.	No.	Tonnage.
Total steam-vessels	677	879,132	691	897,153
Total sail-vessels	307	198,887	282	187,876
Total vessels	984	1,085,029	973	1,085,029

Imports and exports at the port of New Orleans, La., from July 1, 1885, to June 30, 1886, inclusive.

IMPORTS.

Merchandise, free	$4,740,969
Merchandise, dutiable	3,349,800
Total, free and dutiable	8,090,769
Gold coin and bullion:	
Gold bars	$9,640
Other bullion	44,190
American coin	500
Foreign coin	1,400
Silver coin and bullion:	
Bullion	7,300
American coin	9,597
Foreign coin	116,808
Total, coin and bullion	189,435

EXPORTS.

Foreign merchandise	1,036,416
Domestic merchandise	81,532,468
Total	82,568,884

Total duties on imports for fiscal year ending June 30, 1886, $1,303,520.93.

Very respectfully,

B. F. JONAS, *Collector.*

Maj. CHAS. W. RAYMOND,
United States Engineer

IMPROVEMENT OF THE MOUTH OF RED RIVER AND RECTIFICATION OF THE RED AND ATCHAFALAYA, AT THE MOUTH OF RED RIVER, LOUISIANA.

No work in pursuance of any project for the permanent improvement of the rivers in this locality has been done.

A project was prepared by the Mississippi River Commission, and is published in their report for 1884, but no instructions as to the carrying out of this plan have been received.

In the latter part of July, 1885, those interested in the maintenance of navigation through Old River became apprehensive that it would be suspended, owing to the rapid fall of the Mississippi River, and requested that steps be taken to maintain the low-water channel.

The funds on hand were not sufficient to undertake any work, but on August 28 instructions were received from the President of the Mississippi River Commission to commence work, and an allotment of funds was made by the Commission.

The steamer General Newton, belonging to the work of improving harbor at New Orleans, was put in commission and prepared for the work. An iron scraper made of boiler-plate, 16 feet wide and 3 feet high, strongly braced, was constructed. This scraper was attached to the bow of the Newton in such a manner that it could be raised and lowered by means of a proper derrick frame.

The Newton, with a light-draft barge and a barge of coal, left New Orleans September 5, and arrived at Red River Landing on the 7th. A pile-driver and three small barges, kindly loaned by Captain Sears, from the third district, arrived at Red River Landing on the 5th, where the launch Ruby, with a quarter-boat, had been previously sent from Natchez.

An examination was made on September 7, which showed only 4½ feet on the crest of the bar at the mouth, and from 7 to 17 feet through Old River. The Red River Landing gauge read 12.30, and the Barbre's Landing gauge 7.9.

The scraper was immediately put to work on the bar at the mouth, and in three or four days made a channel whose least depth was between 8 and 9 feet, which proved it to be very effective.

The pile-driver and barges were taken into Old River, and commenced at once to construct light dike work for contracting the channel between Chandler's and Barbre's. These dikes were built of very small piles driven in two rows, and the space between the rows filled with willows ballasted with sand bags. They answer the purpose for which they are intended during the low-water season, and are swept away during the flood season, leaving no obstruction.

During a temporary rise of the river the scraper work was suspended on September 11, and the dike-work after two dikes had been constructed. The plant was laid up at Red River Landing, and a small force retained to make repairs necessary to have all in readiness for resuming work when the falling river should make it necessary.

The river commenced to fall on September 28, and on October 7 there was 8 feet on the bar at the mouth. The General Newton was put to work with the scraper on the 8th, with 6 feet scant, and on the evening of the 9th had secured a good 8-foot channel.

Additional dikes were constructed between Chandler's and the head of the Atchafalaya, and at the mouth of Old River a dam 225 feet long was built, to close an opening in the bar, that the current might be concentrated in the scraped channel.

On October 29 an examination was made and soundings taken from the mouth of Old River to the head of the Atchafalaya. The least navigable depth was found to be 4½ feet at intervals, but the channel was very narrow. All steamers in the trade continued to run as usual. On this date (October 29) the Red River Landing gauge read 6.4, and the Barbre's Landing 1.5, against 12.30 and 7.9, respectively, on September 7, when work was commenced with 4½ feet on the bar at the mouth. From this it will be seen that portions of the channel of Old River would have been dry, and navigation entirely suspended, but for the work done by the United States.

On November 3, the river having commenced to rise, scraping was discontinued, and on the 10th dike construction was suspended. The piles in the temporary dikes and the dam at the mouth of Old River, which might prove obstructions at a higher stage of water, were removed as far as possible, and barrel buoys placed on the sites. The plant was overhauled, put in good condition, and returned to the points from which it was taken.

The season's work closed on November 30, since which time there has been nothing done except care of property and office work.

The gauge at Barbre's Landing has been read during the year.

The work is in the collection district of New Orleans, which is the nearest port of entry.

COMMERCIAL STATISTICS.

All the river commerce of the Red River, Bayous Tensas and Macon, Ouachita and Black Rivers, the Atchafalaya, Bayous Courtableau and Des Glaizes, together with numerous tributaries and a large portion of the commerce of Bayou Têche, passes through Old River. Several lines of steamers run regularly in the trade. The total value of the commerce to be benefited by the improvement amounts to over $40,000,000 annually.

The amount which can be profitably expended during the year ending June 30, 1888, cannot be stated until work upon a definite plan is inaugurated. To maintain navigation between the Mississippi and the Red and Atchafalaya by the temporary devices heretofore used would require an estimated annual appropriation of $25,000.

FINANCIAL STATEMENT.

Improving Mississippi River (no limit)—Mouth of Red River.

Balance on hand July 1, 1885	$ 3,816 08
September 7, 1885, amount allotted	7,000 00
November 9, 1885, amount allotted	3,500 00
November 16, 1885, amount allotted	1,400 00
Total	15,716 08
July 1, 1886, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1885	11,351 65
July 1, 1886, balance on hand	4,364 43

IMPROVEMENT OF THE MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

No work has been done in this vicinity, owing to the lack of funds.

The approved project contemplates the protection of the caving banks by means of submerged sloping spurs placed at intervals to be determined as the work progresses, but assumed for estimate of cost at 1,000 feet. The estimated cost is $600,000.

To prevent the flow of water across the neck of land between Giles and Cowpen bends, and the anticipated destruction of the harbors of Natchez and Vidalia by a cut-off, it is proposed to construct a levee at an estimated cost of $100,000. This makes the total estimates $700,000.

The amount which can be profitably expended during the year ending June 30, 1888, is $250,000 for the purchase of the necessary plant, the construction of the levee, and commencement of dike work.

There is received annually at Natchez, Miss., about 40,000 tons provisions, groceries, and machinery, 7,000 tons cotton seed, 25,000 tons coal. The shipments are about 40,000 bales cotton, 4,000 tons oil products. About twelve hundred steamers arrive and depart.

At Vidalia the receipts are 8,000 tons produce, provisions, machinery, etc., and the shipments 10,000 bales cotton and 2,000 tons cotton seed. A railroad recently completed to Trinity, La., will add materially to the commerce of Vidalia.

The work is in the collection district of New Orleans, which is the nearest port of entry.

FINANCIAL STATEMENT.

July 1, 1885—Balance on hand	$1,625 95
July 1, 1886—Amount expended, exclusive of outstanding liabilities July 1, 1885	625 30
July 1, 1886—Balance on hand	1,000 65

CONSTRUCTION AND REPAIR OF LEVEES.

The project of levee building adopted by the Mississippi River Commission has so far been simply to close the existing gaps in the lines already established by constructing levees as far as the funds allotted will permit, with locations of reasonable permanence

and grades equal to the adjacent levees. While proceeding under this plan, the loss of levees by caving banks and their breaching by floods may be annually anticipated.

At the beginning of the fiscal year no embankment construction was in progress; the levees generally throughout the district were in better condition than at any time in the previous twenty years. Lack of funds has prevented any new work being undertaken during the past fiscal year.

The sinking of Kempe Levee, at Potter's Slough, necessitated some repair work being done during the months of February and March, 1886. The embankment was placed in good condition, but it again settled, and additional work was necessary in April and May, 1886.

The parochial authorities of Tensas Parish have raised the grade and enlarged the cross section of the following United States levees: Point Pleasant, Shipp's Bayou to Hard Times, Hardscrabble, Bondurant, and for about two-thirds of the length of the United States Kempe Levee.

The rapid caving of the bank occasioned a gap in the United States Bondurant Levee, and a new piece of levee was built by the State and parish to close it.

The flood of 1886 did not severely strain the levees of the district, and no breaks have occurred in the levees built by the United States.

The lines of levee are now continuous throughout the district, with the following exceptions:

Diamond Island Bend, a gap about 50,000 feet long.
Bougere Bend, a gap about 23,400 feet long.
Black Hawk to Red River, a gap about 90,000 feet long.
Morganza Crevasse, a gap about 6,000 feet long.

Maps showing on one sheet the location, profile, and cross-section of nearly all the levees have been made.

The extensive plant and outfit required in the prosecution of levee work by hired labor has been cared for and repaired, and is in first-class condition for service.

The commerce benefited is all that of the lower Mississippi River.

The work coming under the general appropriation for improving the Mississippi River from Cairo to the Head of the Passes, no separate appropriation is asked for.

FINANCIAL STATEMENT.

Improving Mississippi River (no limit).

A.—Levees, Atchafalaya Front:		
July 1, 1885, balance on hand		$9,496 07
Nov. 16, 1885, transferred to levees Tensas Front	$3,400 00	
Nov. 16, 1885, transferred to mouth of Red River	1,400 00	
Nov. 16, 1885, transferred to harbor at New Orleans	1,400 00	
		6,200 00
		3,296 67
July 1, 1886, expended during fiscal year, exclusive of outstanding liabilities July 1, 1885		2,784 72
July 1, 1886, balance on hand		511 35
B.—Levees, Tensas Front:		
July 1, 1885, balance on hand		611 76
Nov. 16, 1885, amount allotted		3,400 00
June 16, 1886, amount allotted		1,000 00
		5,011 76
July 1, 1886, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1885		3,598 04
July 1, 1886, balance on hand		1,413 72

Approximate value of plant belonging to the United States and used upon the improvement of Mississippi River, fourth district.

Class of property.	Approximate value, June 30, 1886.
Steamer General Newton	$8,900
Steam-tug Tilda	4,100
Steam-launch Ruby	3,500
Steam-launch Alaska	2,550
Two quarter-boats	2,700
Fifteen barges	22,200
Seven skiffs, row-boats, &c	160
Tools and appliances	4,206
Office furniture	535
Surveying instruments	1,057
Miscellaneous	1,729
Total	51,637

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SUPPLEMENTAL REPORT OF THE MISSISSIPPI RIVER COMMISSION.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE, ARMY BUILDING, 33 W. HOUSTON STREET,
New York, November 30, 1886.

SIR: In pursuance of the provisions of section 4, river and harbor act of August 5, 1886, I have the honor to submit the following report of operations under the direction of the Mississippi River Commission, from July 1 to November 1, 1886, with financial statements relating to the appropriations in the said act.

The time which has elapsed since the meeting of the Commission, September 16–20, 1886, has sufficed only for the preparations necessary to carry out the approved projects for the expenditure of the allotments made at that time and recommended for approval.

(1) Appropriation for survey of the Mississippi River from the Head of the Passes to its headwaters: Continuing survey thirty thousand dollars.

The appropriation being too small to permit the extension of field surveys, the work done has been confined to reducing and preparing for publication the data already in hand.

FINANCIAL STATEMENT.

July 1, 1886, balance of old appropriations		$111 21
August 5, 1886, appropriated		30,000 00
		30,111 21
Expended since July 1, 1886	$2,730 68	
Outstanding liabilities	1,879 92	
		4,610 60
Balance available November 1, 1886		25,500 61

(2) Appropriation for improving Mississippi River from Head of the Passes to the mouth of the Ohio River: Continuing improvement, two million dollars.

FIRST DISTRICT.

[Cairo to foot of Island No. 40—200 miles.]

No work has been done in this district except repairs of plant. The works already constructed remain unchanged, and a good navigable channel is maintained. Examinations made at low water disclose the fact that the revetments at Ashport and Craighead Point, which were supposed to have been carried away, are still in place and entire.

SECOND DISTRICT.

[Foot of Island No. 40 to mouth of White River—180 miles.]

In addition to repair of plant, the work done in this district has been in pursuance of an approved project for "completing the work in the river at Memphis," involving the construction of a mattress revetment in front of the city levee, beginning at the lower end and extending up-stream as far as the appropriation will permit. This was begun October 23, and at the end of the month 400 feet had been completed.

THIRD DISTRICT.

[Mouth of White River to Warrenton, Miss.—220 miles.]

Operations in this district have been limited to repair of plant and preparations for work at Delta Point.

FOURTH DISTRICT.

[Warrenton to Head of the Passes—484 miles.]

The principal work done in this district has been upon the channel of Red River, between the Mississippi and the head of the Atchafalaya. This was begun August 9, and continued with success until September 29, when sliding of the banks began to force up mud lumps and ridges in the channel. An attempt was made to remove these by blasting with dynamite, but the rapid fall of the Mississippi, which finally reached a stage 3 feet lower than last year, caused this method to fail, and by October 28 navigation was suspended.

Besides this no work has been done, except in preparation for laying a sill in the Atchafalaya, and for continuing the spurs in New Orleans Harbor, according to the approved projects.

GENERAL SERVICE.

Operations have been almost entirely confined to the preservation and repair of plant. On October 12, informal agreement was made with Mr. George Blackman, of Saint Louis, for 3,600 cubic yards of riprap stone at 54 cents per yard, for the use of Captain Leach, at Memphis, and 1,900 yards of this has been sent to its destination.

FINANCIAL STATEMENT.

July 1, 1886. Balances of old appropriations:		
First district	$1,527 02	
Second district	7,033 64	
Third district	8,057 44	
Fourth district	9,297 80	
General service	20,816 89	
		$46,732 79
Appropriated August 5, 1886		2,000,000 00
		2,046,732 79
November 1, 1886. Expended since June 30, 1886:		
First district	$5,602 10	
Second district	9,126 24	
Third district	14,870 97	
Fourth district	15,309 80	
General service (unapportioned)	1,704 76	
		$46,613 87
Balance available November 1, 1886		2,000,118 92

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Colonel of Engineers, Bvt. Maj. Genl., U. S. A.,
Prest. Miss. River Comm.

The SECRETARY OF WAR,
(Through the Chief of Engineers.)

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
December 4, 1886.

Respectfully forwarded to the Secretary of War.

JOHN G. PARKE,
Acting Chief of Engineers.

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ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

LETTER OF THE SECRETARY OF WAR.

WAR DEPARTMENT,
Washington City, December 29, 1887.

The Secretary of War has the honor to transmit to the House of Representatives the annual report of the Mississippi River Commission for the fiscal year ending June 30, 1887.

WM. C. ENDICOTT,
Secretary of War.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

REPORT.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, December 14, 1887.

SIR: The Mississippi River Commission has the honor to submit a report for the fiscal year ending June 30, 1887, embracing the following subjects:

(1) Surveys and examinations.
(2) Construction.
(3) Financial statements.
(4) Estimates for the fiscal year ending June 30, 1889.
(5) General observations.

SURVEYS AND EXAMINATIONS.

At the close of the last fiscal year the appropriation for surveys and expenses of the Commission was practically exhausted. The act of August 5, 1886, contained an appropriation of $30,000 for surveys of the Mississippi River, which, although too small in amount to justify a

resumption of field work, enabled work to be resumed in the office of the Commission, and it has been prosecuted throughout the year. Work has been mainly on the still incomplete maps of the surveys below Cairo. In addition, the map of the Alluvial Valley has been published, and the results of the discharge observations of 1885 have been tabulated, besides much miscellaneous work. There still remains much to be done in this line before the great mass of information of all kinds collected by the Commission can be published. While its actual cost in money has been several hundred thousand dollars, its actual value can not be even estimated, embodying as it does the most extensive collection of hydraulic observations and data of which there is any record. It should be published with as little delay as possible, if only to insure its preservation. The survey of the Mississippi River below Cairo is now completed. It has been begun above that point, and partially completed to Grand Tower, Ill., while the triangulation has been carried to Keokuk, Iowa, and the levels to Fulton, Ill. The completion of this great work is of the greatest importance, and should be pushed with as great celerity as is compatible with economical execution.

(For details, see report of Capt. S. S. Leach, Corps of Engineers, secretary of the Commission, Appendix A.)

CONSTRUCTION.

FIRST DISTRICT.

(Cairo to foot of Island No. 40. Officer in charge, Capt. S. S. Leach, Corps of Engineers; headquarters, Memphis, Tenn.)

This district includes the work on Plum Point Reach, and at the harbors of Columbus and Hickman, Ky.

Harbors of Columbus and Hickman, Ky.—Special appropriations of $18,750 were made for each of these two harbors by the river and harbor act of August 5, 1886, but as the sums so appropriated were considered by the Commission entirely too small to commence the work needed, it was recommended by the Commission to the Secretary of War that the money be not expended.

Plum Point Reach.—At the end of the last fiscal year the current allotment for this work was about exhausted. As the season was far advanced, orders were given immediately after the passage of the river and harbor bill to put the plant pertaining to the reach in condition for service. This was done.

In September, $377,250 was allotted for work on the reach, and projects were prepared and approved by the Commission for its expenditure. These projects were not approved by the Secretary of War, presumably for reasons to which reference will be made later, and in consequence there has been but little work done on the reach. In December a project for repairs to the Bullerton and Plum Point dikes was approved by the Secretary of War, and the repairs to the Plum Point dikes were carried out. Before work could be begun on the Bullerton dikes they were breached by heavy masses of drift, and subsequent examination shows them to be beyond the reach of repair. No scour has taken place in the chute of Bullerton towhead, but as a matter of precaution a new dike will be built below the site of Dike No. 2. All these dikes were greatly weakened by the decay of the piling used in their construction.

The revetment at Fletcher's Field still remains in place and substantially holds the line of bank. The middle section lost about 500 feet during the year, and, as it is attacked by eddies at both ends, owing to

the incomplete condition in which it was left, its destruction is only a question of time, when undesirable changes will take place in the channel below. The Commission intended to complete this work, but their action was not approved, as stated above.

An allotment of $100,000 was made by the Commission to construct a levee on the upper side of Plum Point, to cut off the large volume of water which in times of flood flows across this point, and force it to follow the main channel. This levee was fortunately completed before the flood of 1887, and its good effect has been very marked. There has been a concentration and deepening of channel throughout the reach, the bars being cut down 8 or 10 feet, with a material lowering of the high-water slope. It is expected this year to partially complete a levee on the opposite or right bank, with the object of cutting off any outflow in that direction also. The effect of these levees, combined with that of the contraction works at Plum Point, Bullerton, and Osceola, will probably soon cause the total disappearance of Plum Point Bar. Its improvement has been steady from year to year, as the concentration of scour cuts the channel down through the old deposits. During the last low water not less than 10 feet depth was found, and this only for a very short time. At extreme low water the depth was from 12 to 13 feet.

(For details of work, see report of Capt. S. S. Leach, Corps of Engineers, in charge of first district, Appendix C.)

SECOND DISTRICT.

(Foot of Island No. 40 to mouth of White River. Officer in charge, Capt. S. S. Leach, Corps of Engineers; headquarters, Memphis, Tenn.

The allotments for this district being exhausted at the end of the last fiscal year, an early allotment of funds was made immediately after the passage of the river and harbor bill of August 5, 1886, to enable the plant to be repaired.

Memphis Harbor.—Work at this point has been carried on with the specific appropriation of $57,250, made by the general act, and has consisted in extending the revetment of former years in front of the paved city levee. The total extent of this work is over 7,000 feet, and about 3,000 feet has been completed during the current season. There remains only a small gap of 600 feet, which will be filled this fall. This work has given entire satisfaction.

Below the paved levee the bank has of late years been caving, seriously threatening the railroad tracks and much valuable property. There being no immediate prospect that the necessary work of protection would be undertaken by the United States, the private parties interested raised the sum of $60,000 to carry out the work themselves. The district officer, Captain Leach, was put in charge of the work and the use of Government plant was authorized. The protection consists of a revetment in the form of five submerged spurs, projecting from the bank and extending from the high-water mark to the limit of scour. They are built of cribs filled with brush and stone, and rest on wide foot-mattresses of brush. The spurs cover a length of 2,200 feet of bank, and their effect has been good, the caving being reported as stopped. The method is substantially the same as that which has already given good results at New Orleans. It is understood that it is intended to put some short spurs between the main ones, to hasten deposit.

Memphis Reach.—The only work here is the revetment at Hopefield Point, for which an allotment has been made. The caving of the un-

protected part of Hopefield Point has continued, and 500 feet of the lower end of the revetment has been carried away. As soon as the river is low enough, the current allotment will be expended in repairing and continuing this revetment down-stream.

Levees.—In this district are embraced the levees of the Upper Yazoo and White River fronts. On the Upper Yazoo front the work done by the United States consisted mainly in strengthening and raising the levees at points where it was most needed, especially in that portion of the line lying between the Hushpucana and the Coahoma County line. By the united efforts of the United States and the State levee authorities, nearly the entire line was brought up to grade, 3 feet above high water of 1882, and was held during the flood of 1887.

Nothing was done on the White River front.

(For details of work see report of Capt. S. S. Leach, Corps of Engineers, in charge of second district, Appendix D.)

THIRD DISTRICT.

(Mouth of White River to Warrenton, Miss. Officer in charge, Capt. W. T. Rossell, Corps of Engineers; headquarters, Memphis, Tenn.)

Lake Providence Reach.—No work has been done in this reach beyond care of plant and carrying on surveys. An allotment of $270,000 was made by the Commission for work here, but the project for its expenditure was not approved by the Secretary of War. The dike work on the reach has been somewhat damaged, owing to the gradual decay of the piling; and the revetment at Pilcher's Point, after holding the bank through two great floods, in spite of its badly damaged and incomplete condition, has now substantially disappeared. The caving of the bank at Elton has allowed the Stack Island channel to split, a portion now going down the shore by Lake Providence. In consequence of this division the depth heretofore found here has diminished. There has also been heavy caving at Ben Lomond and at Wyly's, which will be detrimental unless soon checked.

Vicksburg Harbor.—As soon as the Commission could act on the appropriation of 1866, an allotment was made for some slight repairs needed by the revetment at Delta Point, and a survey was ordered of the harbor and vicinity, to enable the Commission to act on the special and conditional appropriation for work here made by the general act. As a result of this survey, a project was prepared by the district officer for dredging a basin in front of the city, and a canal thence to the river at Kleinston. It was also proposed to build a pile and brush dike across the harbor beyond the end of the basin, and also along the bar from De Soto Island to near the mouth of the proposed canal; the object of these two dikes being to cut off the eddy current which now flows into the harbor at high water and brings in the mud deposit. This project was not acted on at the end of the fiscal year, but has since been approved, and work will be begun as soon as the conditions are favorable.

Greenville Harbor.—For this work a special appropriation of $37,500 was made in the general act. This was not deemed sufficient by the Commission to begin the extensive work of bank protection required, and hence nothing was done during the year. Recently, however, the city has raised $50,000 to put into the work on condition that the expenditure of the appropriation be allowed. As this is deemed sufficient to warrant beginning the work, the Commission have given their approval, and the work will be undertaken at once. Submerged spurs will be used, as at Memphis and New Orleans,

Levees.—This district includes the levees on the Lower Yazoo front and the upper part of the Tensas front. In the former portion only a loop in the levee, rendered necessary by the caving at Ben Lomond, was constructed. On the Tensas front the levee from Amos Ridge to Arkansas City, which covers the head of the Tensas Basin, was partially constructed, being pushed under great difficulties, so as to keep out the flood of 1887, although from 12 to 18 inches higher than any known flood at this point. The reconstruction of the Panther Forest Levee from Gaines Landing to Linwood has been undertaken, but it is not yet completed, and the gap in the levee at Lelands has been closed.

In addition to the work mentioned, work under the supervision of the engineers of the Commission has been carried on by the State and county authorities of Arkansas and Louisiana, the allotments for this portion of the Tensas front, *i. e.*, above the Louisiana State line, having been made conditional on work being done by the parties mentioned, equal in extent to that done by the Commission, and under the supervision of its engineers. During the flood of 1887, considerable work was done in holding the levees, and no break of any magnitude occurred.

(For details of work see report of Capt. W. T. Rossell, Corps of Engineers, in charge of third district, Appendix E.)

FOURTH DISTRICT.

(Warrenton, Miss., to head of Passes. Officer in charge, Maj. C. W. Raymond, Corps of Engineers, to December 4, 1886; since that date, Capt. D. C. Kingman, Corps of Engineers; headquarters, New Orleans, La.)

New Orleans Harbor.—The last work done at this place had been the construction of a system of submerged spur-dikes, designed to stop the caving of the bank in Gouldsboro, Bend, opposite New Orleans. The results of this work appearing satisfactory, it was determined to carry the work on in continuance of the plan, with the special appropriation of $75,000 made by the general act of August 5, 1886. Of the whole number of spurs projected (six in all), two, viz, Nos. 2 and 3, had been entirely completed, and one (No. 5) partially so. During the past year two more spurs were built (Nos. 1 and 6), but the high water intervened before the unfinished No. 5 could be completed. This work has so far proved satisfactory, and it is proposed to continue it as fast as funds are supplied.

Rectification of Red and Atchafalaya rivers.—At the close of the last fiscal year the appropriation for this work was exhausted, and much anxiety was felt as low water approached lest the navigation through Old River should be stopped before funds were available to keep and channel open. As soon as possible after the passage of the river the harbor bill, arrangements were made for beginning work, and on August 17 the plant was on the ground. From this date until October 28 work was steadily pushed, the method being the same as in recent years, viz, scraping on the shoals and building small brush wing-dams at the wider places. The work was more difficult than ever, and the extent of shoal water greater. On September 29 the banks near Ash Cabin began to slide in, the bottom coming up in lumps which finally required blasting for their removal. The struggle was kept up for a month longer, when it was abandoned, and Old River remained impassable until the Mississippi River rose again.

Under the special appropriation for work at the head of the Atchafa-

laya, it was decided to begin the construction of the sills projected to check its further enlargement. These sills, six in number, are submerged brush-dams, placed at intervals of about one-fourth mile. They extend from high-water mark on one bank clear across the stream to high-water mark on the other bank. Their shape and height are so arranged that, while adequate width and depth are left for the passage of boats at low water, the high-water section is only intended to pass an equivalent of the flood-volume of Red River, viz, about 200,000 cubic feet per second. Surveys for the sites of these dams have been made, and plant for the work prepared. It is expected that one sill will be built during the coming season.

Levees.—This district includes the levees on the lower Tensas and Atchafalaya fronts. On the former front work was confined to repairs of the Kempe, Hard Times, and Greens to Fairview levees.

On the Atchafalaya front the Morganza levee was built by the State of Louisiana and the Commission; the latter allotting $40,000 for the work.

(For details of work in this district, see report of Capt. D. C. Kingman, Corps of Engineers, in charge of fourth district, Appendix F.)

GENERAL SERVICE.

All the steamers and barges belonging to this service were repaired, and such supplies of stone as were needed were furnished to the district officers. The fleet was wintered safely at Chester, Ill.

(For details of this work and general financial statement, see report of Lieut. James L. Lusk, secretary of construction committee, Appendix B.)

OPERATIONS FOR THE COMING SEASON.

The rigid interpretation of the restrictions in the river and harbor act concerning the use of bank protection narrows very materially the field of work open to the Commission. They do not deem it advisable to push any further the construction of contraction works while the restriction prevents the holding of banks, even where necessary to protect the contraction works themselves as well as to prevent further deterioration of the channel. Hence, work on the Plum Point and Lake Providence reaches will be confined to repairs to existing works. At Memphis the Hopefield revetment will be repaired and extended, and the Memphis revetment will be completed. At Greenville and Vicksburg work under the special projects, already described, will be carried on, as also at New Orleans and at the head of the Atchafalaya. All funds remaining available, over and above what is required for current repairs and for the care of plant, will be alloted to the construction of levees. It is expected that, with the assistance of local authorities, the Yazoo and Tensas fronts will be entirely closed, and progress will be made on the White River front. The local levees on Plum Point Reach will be extended.

FINANCIAL STATEMENT.

Appropriation for salaries and expenses, Mississippi River Commission.

Balance on hand July 1, 1886	$3,538.79
Expended from July 1, 1886, to June 30, 1887	37.65
Balance on hand July 1, 1887	3,501.14

Appropriation for surveys, Mississippi River.

Balance on hand July 1, 1886	$111.21
Appropriated, act of August 5, 1886	30,000.00
Total	30,111.21
Expended from July 1, 1886, to June 30, 1887	19,630.16
Balance on hand July 1, 1887	10,481.05

Appropriation for improving Mississippi River.

Balance on hand July 1, 1886	$115,871.50
Appropriated, act of August 5, 1886 (less $5,942.60, expenses office Chief of Engineers)	1,994,057.40
Received from sales	29.00
Total	2,109,957.90
Expended from July 1, 1886, to June 30, 1887	707,021.07
Balance on hand July 1, 1887	1,402,936.83

Estimate of funds for the Mississippi River Commission for the fiscal year ending June 30, 1889.

FOR SURVEYS AND EXPENSES.

For continuation of surveys of the Mississippi River between the head of the Passes, near its mouth, and its headwaters, now in progress; to make additional surveys and examinations and investigations, topographical, hydrographical, and hydrometrical as are necessary for maturing a plan for the permanent improvement of the entire river; and for salaries and traveling expenses of the Mississippi River Commission, and of assistant engineers under them, and for office expenses and contingencies	$200,000

FOR IMPROVING MISSISSIPPI RIVER.

For continuing the improvement of the Mississippi River, from Cairo, Ill., to the head of the Passes, including the improvement of the Red River, at and below the head of the Atchafalaya	$5,000,000
For the improvement of the following harbors:	
Columbus, Ky	61,750
Hickman, Ky	251,750
Greenville, Miss	148,500
Vicksburg, Miss	282,500
New Orleans, La	608,600
For the protection of Lake Bolivar levee	150,000
	6,503,100

GENERAL OBSERVATIONS.

There are some features of that clause of the act of August, 5, 1886, containing the appropriation for the Mississippi River below Cairo, and some facts relative to the expenditure of that appropriation, to which attention is invited and which will require a somewhat extended explanation. The clause referred to is in these words:

Improving Mississippi River from Head of the Passes to the mouth of the Ohio River: Continuing improvement, $2,000,000; which sum shall be expended under the direction of the Secretary of War, in accordance with the plans, specifications, and recommendations of the Mississippi River Commission: *Provided*, That no portion of this appropriation shall be expended to repair or build levees for the purpose of reclaiming lands or preventing injury to lands or private property by overflows; *Provided, however*, That the Commission is authorized to repair and build levees, if, in their judgment, it should be done, as part of their plan to afford ease and safety to the navigation and commerce of the river and to deepen the channel; *And provided further*, That no works of bank protection or revetment shall be executed in said reaches or elsewhere until after it shall be found that the completion of the permeable contract-

ing works and uniform width of the high-water channel will not secure the desired stability of the river banks: *Provided, however*, That nothing herein contained shall prevent the construction of revetment works where the banks are caving at Greenville Reach, Delta Point, in front of the cities of Vicksburg, Memphis, Hickman, and Columbus; *And provided further*, That contraction works shall be built at the same time in the wide portions of the river immediately above the said revetment works.

Of the amount herein appropriated for the Lower Mississippi $75,000 are to be expended in continuing the work in progress at New Orleans, $187,500 for the rectification of the Red and Atchafalaya rivers by preventing further enlargement of the latter stream and restricting its outlet capacity, and for keeping open a navigable channel through the mouth of Red or Old River into the Mississippi; $37,500 in improving navigation in the Greenville Reach by preventing the bank at Greenville from further caving; $75,000 in deepening the channel at Vicksburg by dredging through the bar existing there; but this last-named sum shall not be expended unless, after another examination or survey, the Commission shall deem it advisable; and if they shall not, then $37,500 shall be expended in the improvement of navigation at Vicksburg by constructing suitable dikes and other appropriate works; and $56,250 in completing the work on the river at Memphis; also $18,750 for work on the river at Hickman, and $18,750 for work on the river at Columbus, Ky.

The Commission was at much loss to know how to execute this law. Its literal execution was impossible, as will appear clearly from the following facts:

As originally recommended, and so far carried on, the plan of improvement of the Mississippi River embraced three distinct kinds of work, viz:

(1) Contraction works for the purpose of closing chutes and narrowing the channel where necessary, for concentration of the low-water discharge.

(2) Revetment, or bank-protection works, for the purpose of preventing caving of the banks at points where such caving, if unchecked, would make it impossible to obtain the desired contraction of the low-water channel, or result in injurious changes of current direction below.

(3) Levees, designed to limit the high-water width of the river, and, by concentration of the flood discharge within the channel, secure its deepening and enlargement by scour.

This plan was fully set forth and explained in the early reports of the Commission, and received the approval of Congress. It was followed consistently in the expenditure of all appropriations preceding the last. In this the proviso appeared which is quoted above, imposing a conditional limitation upon the use of works for revetment or bank protection. This proviso forbids the use of bank protection anywhere "until after it shall be found that the completion of the permeable contracting works and uniform width of the high-water channel will not secure the desired stability of the river banks."

Literally construed, this was a direction by Congress to stop one branch of the work embraced in the general plan heretofore followed, and go on with the other two to completion first. The "uniform width of the high-water channel," referred to in the proviso, is a thing attainable only by the completion of a general levee system—a work requiring many years and large sums of money for its execution. The object of the permeable contracting works is to narrow the channel. There is a theory afloat in the world that a stream whose channel is regulated in width will not erode its banks. And the plain meaning of this proviso in requiring that no bank protection should be used until after it should be found that the regulation of low-water width by contraction works and high-water width by levees "will not secure the desired stability of the river banks," is that this theory shall be applied to the Mississippi River. But this would require, not only the completion of a general levee system, but the completion of a general contraction system through-

out the river or a large part of it. The channel is already narrow in many places; but the banks cave, nevertheless. That this caving can be stopped by narrowing the channel in a few more places is impossible to suppose. The theory referred to rests upon an assumption of general regulation of width, and consequent general uniformity of velocity and sediment charge. It would have been sufficient to disincline the Commission to try so stupendous and costly an experiment, without first laying the subject fully before Congress, that it is, in the opinion of the Commission, utterly visionary and hopeless. But the experiment is one which is impossible even to try. Five years' experience in Lake Providence Reach warrants the statement that it is impossible to narrow the low-water channel in that reach through permeable contracting works alone, by any expenditure of money or continuance of work. The works may be constructed and deposits secured by the thousand acres, but unless held to its place at certain points of impingement, the current will run away from these and leave them utterly useless and ineffectual.

A subsequent proviso of the clause quoted permits the use of revetment at certain places named, viz, Greenville, Delta Point, Vicksburg, Memphis, Hickman, and Columbus; but with the further provision that "contraction works shall be built at the same time in the wide portions of the river immediately above the said revetment works." The work of bank protection proposed at these places was not for the deepening of the channel, but for the preservation of harbors. There is no wide place immediately above either of them which requires contraction for the improvement of the channel. Such works would cost many times the amounts estimated for the revetments proposed in the harbors. The entire sum appropriated by the act for the river below Cairo was $2,000,000. Of this, $468,750 was required to be expended in specified works at New Orleans, Red River, Greenville, Vicksburg, Memphis, Hickman, and Columbus, leaving $1,531,250 to be allotted by the Secretary of War upon the recommendation of the Commission. That sum was insufficient for the construction, or even commencement, by advantageous methods, of works of contraction at the wide places above the harbors named. So that, upon a literal interpretation, that part of the act also was impossible of execution.

In this dilemma, the Commission sought first to give effect to the beneficial purpose of the law by a somewhat liberal interpretation of its language. It was considered not beyond a fair construction of its terms, in view of its manifest object, to take it to mean, not that all works of bank protection should be excluded from the channel improvement until its total failure had demonstrated their necessity, but that revetment might be employed, not as an original means of improvement, but as an adjunct to the contraction works, where its absolute necessity was as plainly to be seen beforehand as it could be after the destruction of the works. At its meeting on September 20, 1886, the Commission recommended to the Secretary of War an allotment of $377,250 for continuance of work in the Plum Point Reach, and $300,000 for continuance of work at the Lake Providence Reach. At the same time the following resolution was adopted by the Commission and forwarded to the Secretary of War with the recommendations:

Resolved, That the Commission, in making the allotments of to-day, have assumed that in the Plum Point and Lake Providence reaches only those revetments should be built which, in the opinion of the Commission, are indispensable to preserve the improvement in the channel already gained, and to repair and preserve the work already done, and have assumed that this is the intention of the law; but if the intention of the law is thought to prevent in these reaches the construction of any revetment whatever, then the Commission would recommend that the allotments made for the

reaches named be not at present expended, save in so far as to secure existing works from further damage.

The allotment for the Lake Providence Reach was approved by the Secretary of War November 11, 1886, and that for Plum Point November 16, 1886. At its meeting on November 27, 1886, the Commission adopted projects for the expenditure of these allotments in the continuation of work in these reaches. The project for Plum Point embraced, among other work, the extension of an unfinished revetment in Fletcher's Bend, and that for Lake Providence the repair and extension of an unfinished revetment at Pilcher's. Both these works are shown and described in former reports of the Commission, and they were both regarded as essential to the maintenance of the contraction works and permanence of the improved channels in those reaches. These projects were transmitted to the Secretary of War with the following letter:

OFFICE OF MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., November 27, 1886.

SIR: The river and harbor act of August 5, 1886, imposed on the Mississippi River Commission the condition—

"That no works of bank protection or revetment shall be executed in said reaches or elsewhere until after it shall be found that the completion of the permeable contracting works and uniform width of the high-water channel will not secure the desired stability of the river banks."

This limitation is based, it is believed, on the theory that a river, if once regulated, will not scour its natural banks. The Commission is somewhat familiar with the opinions and writings of hydraulic engineers, and, so far as it is advised, this theory is totally unrecognized by any authoritative writer on hydraulics. It is universally recognized by such writers that, in general, when a large obstruction is placed on one bank of a river a corresponding wearing away of the opposite bank occurs in consequence. There is no evidence that a regulated river will not cave its banks, and in most cases it is impossible to build permeable contracting works or secure any narrowing of the channel by them without holding the banks in their immediate neighborhood while the work is going on. The unprotected banks would recede while the contracting works were being built. These general views are fully confirmed by the experience of the Commission on the Mississippi River.

The contraction works at Gold Dust, Plum Point, Duncansby, and Baleshed have been followed by caving on the opposite bank, whose immediate result is, by again enlarging the cross-section of the river, to destroy any beneficial results the contraction works might otherwise produce. That such works may secure any valuable permanent contraction, the opposite bank must in general be held by protection works.

In the opinion of the Commission the idea that the Mississippi River can be permanently improved by contraction works alone is purely visionary and theoretical, contradicted by experience and not supported by any good authority. To adopt such a system is, in the opinion of the Commission, to waste public money. Holding these views, the Commission, as engineers, can not recommend to Congress so futile an undertaking.

In the work which has been done in the Plum Point and Lake Providence reaches the plan which has been so frequently and explicitly recommended by the Commission in previous reports, and which embraces the combination of permeable contracting works and bank protection as means of narrowing and deepening the channel, has been applied. The work has been conducted under difficulties which can justly be called extraordinary. Since its commencement a succession of floods have occurred, without precedent, by which the work has been greatly interfered with and large expense and losses incurred. On two occasions the annual appropriation has failed entirely, and in no case except one has it reached the amount recommended. During long intervals of time the works have remained in an unfinished condition, exposed to injuries which under favorable conditions might have been prevented.

Nevertheless, the deepened channel through the improved portions of these reaches has been maintained continuously. The present season has been one of extraordinary low water—the lowest since 1879. In many parts of the river the depth has fallen to 6 feet and under, but in the improved parts of these reaches there has been at all times a navigable channel of ample depth. Before these works were begun these reaches were the worst places on the river. It was for that reason that their improvement was undertaken first in order. They are now good.

These successful and gratifying results have been obtained by the combination of permeable contracting works and bank protection, each supplementing and aiding

the other, and, in the opinion of the Commission, could not have been obtained by permeable contracting works alone. In the act of August 5, 1886, certain restrictions already referred to, not entirely free from ambiguity, are laid upon the use of bank protection or revetment as means of channel improvement. In the recommendations made for the expenditure of this appropriation, the Commission have regarded these restrictions, and have recommended no work of bank protection or revetment that does not seem to them to be absolutely necessary to save from destruction costly work already done or valuable results already obtained, leaving to yourself, at the same time, the final question of the full meaning and intent of the law.

The Commission would call attention to the fact that, Congress having failed at its last session to make any provision for payment of its expenses, and the Attorney-General having decided that such expenses could not be paid from the appropriation, it has been impossible to make such inspections of the work as are much to be desired. The Commission would also call attention to the fact that the works at Plum Point and Lake Providence have seriously deteriorated during the absence of appropriations for carrying them on, and hence that the appropriations asked for in the annual report should be granted, as the works in those reaches are still incomplete and funds are not available for their completion.

Q. A. GILLMORE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
President Miss. River Commission.
C. B. COMSTOCK,
Lieut. Col. Engineers, Bvt. Brig. Gen., U. S. A.
CHAS. R. SUTER,
Major of Engineers, U. S. A.
HENRY MITCHELL,
Coast and Geodetic Survey.
B. M. HARROD.
R. S. TAYLOR,
S. W. FERGUSON.

The SECRETARY OF WAR.
(Through the Chief of Engineers.)

This letter was laid before Congress by the Secretary of War January 25, 1887, but no action was taken upon it of which the Commission is advised. The projects recommended were not approved by the Secretary.

At its meeting held July 2, 1887, the Commission adopted the following resolutions:

(1) *Resolved,* That in view of the non-approval by the Secretary of War of certain of the projects for the improvement of the Mississippi River, under act of August 5, 1886, recommended by the Commission at its meeting in November, 1886, the Commission feels compelled to regard those recommendations so remaining non-approved as disapproved, although no express action to that effect has been communicated to the Commission; and that it is the judgment of the Commission that all recommendations so remaining unapproved should be withdrawn, and new recommendations made for the allotment and expenditure of money covered by said recommendations in other parts of the work clearly authorized by said act, and within the general plan of improvement adopted by the Commission and approved by Congress.

(2) That the judgment of the Commission is that, until further action on the subject by Congress, no work should be done in the channel, except such repairs of existing works as will protect the same from injury; and that so much of the appropriation made by said act not required by its terms to be expended for specific improvements therein named as shall not be needed for such repairs and for the care of plant should be allotted to the construction or repair of levees in those localities where they will contribute most effectually to the improvement of navigation by uniform width of high-water channel.

(3) That the district officers now present be directed to prepare immediately projects for their respective districts, comprising only such work as will be in their judgment necessary and sufficient to protect the works already constructed from injury and provide for the care of plant until the close of the present fiscal year.

The projects prepared by the district officers in obedience to the last of these resolutions showed a balance of $531,140, after providing funds sufficient to protect the works already constructed and for the care of plant to the close of the fiscal year. The Commission then recom-

mended that this sum be allotted to the construction of levees. The entire allotments made to that part of the work out of the appropriation were as follows:

At meeting of September 20, 1886	$400,000
At meeting of November 27, 1886	100,000
At meeting of July 2, 1887	531,140
Total	1,031,140

All these allotments were approved by the Secretary of War.

Except for the restrictions and directions contained in the provisos to which reference has been made, the Commission would have regarded the first allotment of $400,000 as a suitable portion of the entire appropriation to be expended in the construction of levees. But the language of the act, literally construed, was an express direction to complete, or at least go forward with, that part of the work directed by the act which was clearly practicable, and omit that part which was believed to be impracticable until Congress could take further action on the subject. And this was the course taken.

It may be said further that the time is opportune for pushing the levee work with vigor. The full benefit to be expected in the improvement of the channel by concentration of the flood discharge can not be realized without complete closure of long lines of alluvial front. In the early reports of the Commission it was recommended that the closure of the Yazoo and Tensas basins be taken as objective points, and that end has been kept in view throughout the work. In expenditures for the construction of levees the Commission has, as a rule, sought the co-operation of the State and the local authorities and private citizens interested. This course has stimulated the people of the alluvial valley to the most strenuous exertion. The total allotments for levees made by the Commission since its organization, out of the appropriations made by Congress, may be stated in round numbers at $2,600,000. The Commission is not in possession of exact information as to the amount expended in like work, during the same time, by the local authorities and citizens, but estimates the sum approximately at $4,350,000. By means of this co-operation the Yazoo front has been closed, the lines requiring, however, some additions and strengthening before they can be regarded as complete; and the work on the Tensas front is so far advanced that it is hoped that another season will suffice for its completion. The past year has witnessed a great awakening of enterprise in the Yazoo and Tensas basins, stimulated in part, no doubt, by the prospect of protection against overflow, and which in turn will create means and motives for the protection and preservation of the levees constructed. So that, considering it to be part of the plan of improvement that the levees shall be built and maintained for the betterment of the channel, as has been constantly recommended by the Commission, and as is declared in the act last passed, and to be to the interest of the Government that as large a share of the cost as possible shall be paid by the local authorities or the people, it is clear that the present is a favorable time for pressing the work.

The convictions expressed by the Commission in its letter to the Secretary of War, touching the futility of an attempt to improve the river channel by levees and contraction works alone, are still entertained, and have been strengthened by the experience of the present season. It would be impossible for works of improvement to operate more successfully than have those at Plum Point Reach. The regulated channel has maintained its width and depth and the current its location

and direction, with no substantial variation. These results have been obtained by permeable contraction works and works of bank protection combined. They could not have been obtained by either alone. The Commission believes that it would be impossible for any intelligent man to go to the reach and look at what has been done and the results which have been achieved without seeing clearly that that part of the work which has operated, like the key of an arch, to hold all other parts in place has been the revetment in Fletcher's Bend.

At Lake Providence Reach as great depth of channel has been obtained as at Plum Point, but the channel has not retained its location and direction as steadily, and in the present situation there is less promise of permanence of the good results obtained. This is accounted for by the fact that the revetment work in that reach is less complete and has suffered more injury, and that there has been, in consequence, more caving of bends and more shifting of the channel.

The practical execution of works for bank protection upon such large scale and in situations so difficult as those found on the Lower Mississippi was at the beginning a problem transcending the experience of engineers. There was no road to success except by experiment. Since then much valuable experience has been gained, improved methods of construction have been devised, better results have been obtained, and the cost, considering the results, lessened. The form of revetment mostly employed consists of continuous mattress under water, and graded bank, grillage, and stone covering above the low-water line. At New Orleans a revetment has been employed, consisting of submerged spurs placed against the caving bank. This form was cheaper than a continuous mattress would have been at that place, and appears so far to be successful. At the lower portion of the Memphis city front a revetment has been constructed consisting of detached spurs extending to high-water mark. This was more expensive than a continuous mattress would have been at the same place; but in the situation there presented, the bank to be protected being at the foot of a high, crumbling bluff, the spurs seemed to be the better form. This work was done under the direction of Capt. S. S. Leach, the district officer in charge, but mainly at the expense of private citizens. It has passed through one flood without injury and gives every promise of permanent success.

These three forms of revetment—the continuous mattress, the submerged spur, and the spur extending to high-water line—are all that have been tried. A fourth form is possible, consisting of discontinuous mattresses placed at intervals against the bank. It is possible that in some situations this would be found practicable and economical; but it is to be remembered that in such constructions as these experiments in search of cheapness are themselves very expensive.

The Commission is not unaware of the grave responsibility which it assumed in declining to recommend the execution of work in the form contemplated in the proviso found in the act of August 5, 1886; but the Commission was then of the firm opinion, and still is, that the prohibition of all bank protection makes the work of improvement by regulation of the low-water channel impossible. Holding these views, the Commission would be wanting in the faithful discharge of duty if it should fail to urge upon Congress a reconsideration of the subject. It it particularly to be regretted that such a change should be proposed in the conduct of work in the Plum Point and Lake Providence reaches. In these the work done has been a combination of contraction and revetment. It has been successful in the highest degree. It is now near completion. In the absence of unlooked-for disaster, and by prompt

resumption of work with sufficient means, it is believed that $250,000 will suffice to complete the work undertaken at Plum Point and $1,500,000 that at Lake Providence; and against a change of plan at this time, which it is believed will imperil all the good results attained in those difficult reaches, the Commission feels compelled to protest with all the earnestness which is consistent with the respect due to the superior wisdom and authority of Congress.

IMPROVEMENT OF BAYOU PLAQUEMINE.

There is one measure of partial relief to the commerce of the Atchafalaya which may also be of some value to the commerce of Red River, while works for its more complete improvement are going on, which the Commission recommends to the attention of Congress. It is the opening of the Bayou Plaquemine from its junction with the Atchafalaya to the town of Plaquemine, on the Mississippi. There is a considerable and growing commerce in the Atchafalaya Basin, which finds its present outlet into the Mississippi by way of Old River. It is not to be expected that that outlet can be kept open at low water until improvements can be completed that will require several seasons for their finishing. If that commerce could have access to the immediate bank of the Mississippi at Plaquemine it would not be entirely suspended by the closure of Old River; and until the proposed new channel north of Turnbull's Island is developed, it would be some relief to the Red River trade to be able to reach the Mississippi at Plaquemine when Old River is shut up. The expense of such improvement of the Bayou Plaquemine and its connections as would suffice for this purpose would not be great. From information gathered from personal inspection and other sources, the Commission is of the opinion that $40,000 would secure the advantages proposed. If such an improvement is to be undertaken at all, it is very desirable that it shall be completed before the next low-water season, which could not be accomplished after the passage of an appropriation bill at the coming session of Congress in the ordinary course of business. The Commission recommends, therefore, that the Secretary of War be authorized to use at his discretion not exceeding $40,000 of money heretofore appropriated for work in the Atchafalaya and Red rivers, or for the improvement of the Mississippi River below Cairo, in the improvement of Bayou Plaquemine.

Q. A. GILLMORE,
President Miss. River Comm.,
Colonel of Engineers, Bvt. Maj. Gen.
CHAS. R. SUTER,
Lieut. Col. of Engineers, U. S. A.
B. M. HARROD.
R. S. TAYLOR.
S. W. FERGUSON.

The SECRETARY OF WAR,
(Through the Chief of Engineers.)

I am not of the opinion that levees can be used either with economy or usefulness to improve the low-water navigation of the Mississippi River; hence, under the proviso of the river and harbor bill of August

5, 1886, "that no portion of this appropriation shall be expended to repair or build levees for the purpose of reclaiming lands or preventing injury to lands or private property by overflows," I do not concur in the advisability, under the law, of spending on levees nearly two-thirds of the appropriation not limited to specific points.

The value of levees as a means of improving low-water navigation has been much discussed, and some results of experience are very desirable. At Plum Point a levee was built in 1886–'87, which, in the high water of 1887, turned into the river a large amount of flood-water which before had escaped over Plum Point. A cutting down of shoals and enlargement of section in consequence is reported, and was to have been expected. But the question at issue is whether such confinement of flood-waters increases in a marked degree the navigable low-water depths on the *shoalest crossings*. Prior to the construction of the levee, the least depths on the Plum Point crossing had been for some years oftener over than under 9 feet, sometimes reaching 10 or 12 feet. Yet on October 27, 1887, the depth on the Plum Point crossing was but 9 feet, this being eight months after the completion of the levee. The river was very low (—0.5 on the Plum Point gauge), but as the contraction works alone might have cut down the bar to this depth, evidence that this levee has improved navigation is wanting.

The Commission estimate the cost of completing the work in the Plum Point and Lake Providence reaches at $250,000 and $1,500,000, respectively. Even if work were to be confined to the 14 miles at Plum Point, and to the 19 miles at Lake Providence, to which previous work has been mainly confined, I deem these sums much too small. A reach can be considered completely or permanently improved only when its works have been carried so far that the reach and its works are safe for many years against changes within its limits, and when the only danger of any serious injury is from an attack at the upper end of the works by the unregulated river above them. To stop short of this is to increase steadily the amount of work annually destroyed by the river itself.

C. B. COMSTOCK,
Lieut. Col. of Engrs., Bvt. Brig. Genl.

NEW YORK, *December* 9, 1887.

I concur in the above report, except as regards the building of extended levees as means of improving navigation. Our experience with levee construction has led me to the conviction that no general or very extensive system of levees for the Lower Mississippi River would form part of a proper plan for the deepening of the low-water channel at those "crossings," comparatively few, at which there is now less water in the low-river season than commerce requires. I can not, therefore, concur in the statement that "the other branch of the work directed by the act, consisting of levees designed to secure uniform width of the high-water channel, is of such nature that it can be carried forward to any extent in advance of other work, with economy and usefulness."

HENRY MITCHELL.

List of Appendices accompanying the foregoing report.

APPENDICES.

APPENDIX A.

ANNUAL REPORT OF THE SECRETARY OF THE COMMISSION UPON THE WORK OF SURVEYS AND EXAMINATIONS.

OFFICE MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
St. Louis, Mo., July 25, 1887.

GENERAL: I have the honor to submit the following report of operations under the appropriation for "surveys of the Mississippi River" during the fiscal year ending June 30, 1887.

No field work has been done except the regular trips of the gauge-inspector.

Work was entirely suspended until August 6, when the passage of a river and harbor bill enabled my predecessor, Captain Turtle, to employ assistants and others and resume the office work and reductions. The conventional sign work was completed on detail charts below Cairo; 16 sheets, Cairo to Caruthersville having been done during the year, and the printed signs on 24 sheets retouched. Special maps of Plum Point and Lake Providence reaches, called for by the Commission, to show bank-lines to date and illustrate the effect of contraction works upon adjacent caving banks, were prepared.

The "alluvial map," showing areas of overflow and contours of basins, was completed and published. Sheets 1, 2, 3, and half of 4, of the second edition of the 1 inch to 1 mile series of charts, which contain the extended topography of the later surveys, were drawn and preliminary work was done on 5, 6, and 7.

The chart of high-water regimen and the tables of the elements of bank-full and mean-stage sections have been completed and the diagram blue-printed.

The reduction and tabulation of the results of discharge observations in 1885–'86 have been completed. A large amount of other work has been done in the way of consolidations, tabulations, and arrangement of data for publication or ready reference, and in clerical and miscellaneous work consequent upon calls for information from officers and the public.

From lack of funds the force is now so reduced that but little progress can be made towards bringing into shape for use the mass of information now awaiting discussion. That funds should be liberally supplied to enable the compilation of data and the publication of maps to proceed, is a necessity that can not be too strongly emphasized.

The information now on hand in undigested form, or in original copies, subject to destruction by fire or damage by exposure and decay, represents an expenditure of several hundred thousand dollars, which can not be utilized or put beyond danger of entire destruction until further appropriations are made. They should be made for the reasons here given and without reference to any future policy or prospects.

A table of value of plant and financial statements are herewith.

For list of civilian engineers employed see my report for the first district.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers,
Secretary Mississippi River Commission.

General Q. A. GILLMORE,
President Mississippi River Commission.

8872 ENG 87——174

Appropriation for surveys Mississippi River.

FINANCIAL STATEMENT.

Balance July 1, 1886, from appropriation July 5, 1884	$111.
Appropriation, act of August 5, 1886	30,000.
Total	30,111.
Expended from July 1, 1886, to June 30, 1887	19,630.
Balance June 30, 1887	10,481.

General balance sheet.

1886. July 1	To balance from appropriation, July 5, 1884	$111.21	1887. June 30	By amount expended from July 1, 1886, to June 30, 1887	$19,630
	To appropriation act of August 5, 1886	30,000.00		By balance	10,481
	Total	30,111.21		Total	30,111

Itemized statement of expenditures for Mississippi River Commission, act of July 7, 18

Items.	Car tickets.	Washing.	Gas.	Water rates.	Telegrams.	Tot
Office	$5.00	$3.00	$1.80	$25.00	$2.85	$37.

SUMMARY.

Balance July 1, 1886		$3,538
Expended during fiscal year	$37.65	
Liabilities	3,490.95	
		3,528
Balance available		10.

SMITH S. LEACH,
Captain of Engineers,
Secretary Mississippi River Commission.

Itemized statement of expenditures of surveys of Mississippi River, act of August 5, 1886

Items.	Services.		Outfit.	Supplies.	Rent.	Fuel.	Repairs
	Assistant engineers, clerks, etc.	Draughtsmen and gauge keepers.					
Office	$6,541.59	$31.09	$2.70	$71.16	$975.00	$218.54	$19.0
Reduction and publication	5,605.26	1,253.08	33.22	387.22			
Inspection, etc., of gauges	1,004.17	1,070.90		59.71			6.8
Field work of topography	200.00	33.00					
Care of property		125.00					
Total	13,951.12	2,513.07	35.92	518.09	975.00	218.54	25.8

Itemized statement of expenditures of surveys of Mississippi River, etc.—Continued.

Items.	Transportation.	Traveling expenses.	Miscellaneous.	Furniture.	Periodicals.	Stationery.	Mileage.	Total.
es	$23.50	$1.25	$122.80	$93.85	$15.50	$317.91	$292.80	$8,726.82
ection and publication	23.10	5.00	58.38					7,865.26
pection, etc., of gauges	20.15	294.50						2,456.28
ld work of topography	5.00		71.50					309.50
scellaneous surveys								*600.00
re of property								125.00
Total	71.75	300.75	252.68	93.85	15.50	317.91	292.80	19,582.86

* Expended by Capt. Dan. C. Kingman, Corps of Engineers, in survey of Morganza.

SUMMARY.

lance from appropriation of July 5, 1884		$111.21
ppropriated by act of August 5, 1886		30,000.00
Total		30,111.21
xpended for fiscal year ending June 30, 1887	$19,582.86	
eserved by Chief of Engineers, for expenses in his office on account of appropriation	47.30	
		19,630.16
Balance available		10,481.05

SMITH S. LEACH,
Captain of Engineers,
Secretary Mississippi River Commission.

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pproximate value of plant belonging to the United States and used by the Mississippi River Commission in surveys and examinations of the Mississippi River.

[Appropriation for Mississippi River Commission.]

Class of property.	Approximate value June 30, 1887.
ne steamer, *Patrol*	$11,200.00
Three launches, Nos. 1, 3, and 4	4,000.00
One steam-tug, *Frolic* (wrecked during the year)	200.00
Six quarter-boats	9,600.00
Skiffs, etc	350.00
Outfit	3,200.00
Tools and appliances	640.00
Surveying instruments	12,000.00
Drawing instruments	700.00
Office furniture	800.00
Printing press, etc	280.00
Current meters and outfit	1,520.00
Total	44,490.00

[Appropriation for surveys of Mississippi River.]

Three launches, Nos. 5, 6, and 7	$6,000.00
Current meters and outfit	640.00
Outfit	160.00
Tools and appliances	80.00
Total	6,880.00

SMITH S. LEACH,
Captain of Engineers,
Secretary Mississippi River Commission.

A 1.—*Geographical positions of triangulation points in the vicinity of Cairo, Ill., esta[b]lished by the United States Lake Survey in 1876.*

Station.	Latitude.	Longitude.	Azimuth.	Back azimuth.	To station.	Dis-[tance]
	° ′ ″	° ′ ″	° ′ ″	° ′ ″		Meter[s]
North base	37 02 21.94	89 11 31.84	34 11 56.27	214 11 19.37	Missouri	2,695
			352 32 01.98	172 32 07.19	South base	1,646
Greenfield	36 59 01.67	89 11 51.26	188 41 15.60	8 41 32.47	....do	4,56
			294 21 07.77	114 22 15.44	Bird's Ferry	3,03
Missouri	37 01 09.62	89 12 33.12	250 57 39.97	70 58 22.07	South base	1,82
South base	37 01 28.97	89 11 23.19	318 27 21.26	138 28 28.41	Defiance	4,158
			264 43 48.81	84 44 40.51	Ohio	2,13
Ohio	37 01 35.31	89 09 57.33	121 36 43.98	301 35 47.06	North base	2,742
			349 08 08.73	169 08 24.19	Defiance	3,35
Defiance	36 59 47.99	89 09 31.65	67 32 36.97	247 31 12.97	Greenfield	3,735
			262 21 21.35	82 22 01.31	Ferguson	1,636
Bird's Ferry	36 58 20.80	89 09 58.75	193 59 51.66	14 00 07.98	Defiance	2,770
			244 18 25.65	64 19 36.36	Bird's Point	3,225
Bird's Point	36 59 06.14	89 08 01.23	119 59 14.83	299 58 20.42	Defiance	2,581
			319 18 56.70	139 19 31.55	Price	2,198
Ferguson	36 59 55.14	89 08 25.25	338 31 49.53	158 32 03.99	Bird's Point	1,62
			296 08 41.07	116 09 39.01	Fillmore	2,63
Fillmore	36 59 17.21	89 06 48.97	79 12 01.00	259 11 17.52	Bird's Point	1,819
			10 00 36.70	190 00 28.08	Price	2,009
Price	36 58 12.06	89 07 03.30	355 04 44.57	175 04 49.24	Maybee	2,23
			290 19 44.18	110 20 20.91	Willow Creek	1,612
Willow Creek	36 57 53.89	89 06 02.19	38 19 18.24	218 18 46.17	Maybee	2,19
			155 45 12.41	335 44 44.27	Fillmore	2,817.
Maybee	36 56 59.71	89 06 55.54	312 01 06.02	132 01 39.19	Island No. 1	1,83
Island No. 1	36 56 19.79	89 06 00.34	179 05 49.29	359 05 48.18	Willow Creek	2,901

A 2.—*Geographical positions from Mound City, Ark., to Helena, Ark.*

Station.	Latitude.	Longitude.	Azimuth.	Back azimuth.	To station.	Distance
Barton	35 12 16.53	90 06 03.23	12 41 01.52	192 40 46.26	Mound City	3,052.
			311 23 56.82	131 24 59.54	Frame's Chute	3,669.
Frame's Chute	35 10 57.76	90 04 14.43	80 52 08.74	260 50 50.79	Mound City	3,467.
			9 20 47.91	189 20 40.67	Hopefield	1,963.
Mound City	35 10 39.88	90 06 29.73	294 02 03.69	114 03 14.37	.. do	3,399.
Hopefield	35 09 54.93	90 04 27.02	258 29 58.19	78 30 36.98	Wolf River	1,739.
Wolf River	35 10 06.18	90 03 19.66	138 55 24.38	318 54 52.83	Frame's Chute	2,106.
			00 18 16.48	180 18 16.16	Memphis	2,660.
Memphis	35 08 39.85	90 03 20.22	143 51 05.45	323 50 26.99	Hopefield	2,865
			39 58 26.91	219 57 55.32	Peterson	2,162.
Peterson	35 07 46.06	90 04 15.11	167 43 49.62	347 43 42.84	Vance, sr	1,403.
			84 31 19.91	264 30 32.47	Vance, jr.	2,096.
Vance, sr	35 08 30.58	90 04 26.90	48 41 32.64	228 40 51.97	Vance, jr	2,381.
			260 22 56.24	80 23 34.62	Memphis	1,711.
Vance, jr.	35 07 39.56	90 05 37.57	58 50 57.68	238 50 17.79	Davis	2,051.
			104 38 39.78	284 37 39.22	Bayou	3,162.
Forrest	35 06 41.10	90 05 20.36	219 31 16.78	39 31 54.31	Peterson	2,596.
			166 24 23.98	346 24 14.08	Vance, jr	1,853.
Davis	35 07 05.13	90 06 46.91	288 39 35.69	108 40 25.47	Forrest	2,312.
			82 02 52.17	262 01 56.50	Crawford	2,474.
Bayou	35 08 05.49	90 07 38.44	324 57 05.62	144 57 35.27	Davis	2,272.
			73 53 03.93	253 52 06.36	Lake	2,636.
Crawford	35 06 54.00	90 08 23.68	207 28 09.50	27 28 35.53	Bayou	2,482.
			185 56 19.70	5 56 26.43	East base	2,862.
Lake	35 07 41.73	90 09 18.49	316 39 51.46	136 40 22.99	Crawford	2,021.
			39 04 56.16	219 04 27.59	Appersen	1,994.
East base	35 08 26.40	90 09 11.98	76 24 18.23	256 23 29.56	West base	2,202.
West base	35 08 09.59	90 10 36.53	321 37 30.36	141 38 12.27	Crawford	2,971.
Appersen	35 06 51.50	90 10 07.14	268 19 06.09	88 20 06.17	....do	2,645.
			13 27 42.69	193 27 28.36	Jones	2,711.
Leadbetter	35 06 08.40	90 09 31.28	144 54 34.89	324 54 13.69	Appersen	1,623.
			230 36 11.69	50 36 50.57	Crawford	2,214.
			3 12 27.98	183 12 23.37	Ensley's	3,626.
Jones	35 5 25.92	90 10 33.06	230 5 10.46	50 5 45.98	Leadbetter	2,639.
			10 15 06.97	190 14 56.12	Mathews	2,687.
Ensleys	35 4 10.88	90 9 39.29	149 30 23.87	329 29 52.97	Jones	2,683.
			23 56 19.16	203 56 .65	Fleece	2,012.
Mathews	35 4 .11	90 10 51.94	259 46 06.22	79 46 47.96	Ensleys	1,870.
			32 53 09.13	212 52 43.96	Reeves	2,045.
Fleece	35 3 11.19	90 10 11.52	145 48 37.65	325 48 14.43	Mathews	1,822.
			35 28 54.14	215 28 16.06	Watson's	2,896

Geographical positions from Mound City, Ark., to Helena, Ark.—Continued.

Station.	Latitude.	Longitude.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″		*Meters.*
Reeves	35 3 4.37	90 11 35.77	264 22 12.86	84 23 1.24	Fleece	2,145.1
			49 8 47.36	229 8 6.00	Harris	2,413.8
Watson's	35 1 54.65	90 11 17.84	168 3 42.66	348 3 32.36	Reeves	2,195.7
			59 50 5.85	239 49 23.77	Horn Lake	2,149.7
Harris	35 2 13.13	90 12 47.81	284 00 18.30	104 1 9.94	Watson's	2,350.1
			86 24 37.11	266 23 59.73	Patterson's	1,653.2
Horn Lake	35 1 19.59	90 12 30.17	165 39 10.07	345 39 .52	Harris	1,702.5
			94 19 37.16	294 18 3.86	Rock Chute	4,132.1
Patterson's	35 2 9.75	90 13 52.91	306 43 00.63	126 43 47.55	Horn Lake	2,585.1
			89 14 26.84	269 13 5.09	Scanlan's	3,582.7
Rock Chute	35 1 29.67	90 15 13.71	238 54 15.66	58 55 2.06	Patterson's	2,391.5
			91 32 16.40	271 30 55.96	Collins	3,553.9
Scanlon's	35 2 8.14	90 16 14.26	307 42 37.59	127 43 20.50	Rock Chute	1,940
			18 11 1.66	198 10 36.70	Cow Island	3,534
Collins	35 1 32.71	90 17 33.87	241 34 12.46	61 34 58.16	Scanlan's	2,294.4
			13 11 17.97	193 11 4.84	Cow Island Bend	2,546.2
Cow Island	35 0 19.18	90 16 57.76	157 59 56.00	337 59 35.27	Collins	2,443.5
			345 20 13.77	165 20 30.02	State Line	2,839.8
Cow Island Bend	35 0 12.26	90 17 56.78	261 52 26.62	81 53 .40	Cow Island	1,511.7
			345 28 46.92	165 28 57.82	Fairview	1,923.2
Fairview	34 59 11.84	90 17 37.76	206 02 58.82	26 3 10.77	Cow Island	2,310
			322 4 8.43	142 4 48.11	McConnell	2,856
State Line	34 58 50.03	90 16 29.40	111 11 38.52	291 10 59.33	Fairview	1,859.2
McConnell	34 57 58.73	90 16 28.55	179 12 48.71	359 12 48.22	State Line	1,581
			277 50 17.71	97 50 53.75	Nelmo	1,610
			334 35 51.31	154 36 4.93	Cat Island Chute	1,406
Nelmo	30 57 51.60	90 15 25.67	138 5 14.05	318 4 37.52	State Line	2,449.7
Cat Island Chute	34 57 17.51	90 16 4.78	223 21 38.33	43 22 .74	Nelmo	1,444.7
			304 47 13.93	124 48 2.15	Harcklerode	2,600.9
			355 49 26.43	175 49 31.81	Cat Island	3,272.4
Harcklerode	34 56 29.35	90 14 40.59	155 42 58.15	335 42 32.32	Nelmo	2,780.6
			46 50 50.54	226 50 16.71	Cat Island	2,601.8
Cat Island	34 55 31.59	90 15 55.39	300 8 52.51	120 9 16.37	Lamb	1,223.1
			6 5 55.01	186 5 52.61	Grider	1,003.6
Lamb	34 55 11.65	90 15 13.72	199 20 40.17	19 20 59.14	Harcklerode	2,537.2
			71 46 13.77	251 45 47.51	Grider	1,225.8
Grider	34 54 59.21	90 15 59.59	357 5 2.51	177 5 4.11	Star Landing	1,894.2
			54 39 10.41	234 38 27.85	John H	2,314.2
Star Landing	34 54 14.02	90 15 56.80	211 37 2.51	31 37 27.17	Lamb	2,085.6
			91 33 59.30	271 33 15.15	John H.	1,959.3
John H.	34 54 15.75	90 17 13.95	8 25 12.55	188 25 2.32	Williams	3,100.2
			34 4 47.85	214 4 3.62	Horseshoe Lake	3,503.6
Horseshoe Lake	34 52 41.57	90 18 31.27	276 13 30.72	96 14 4.71	Williams	1,518.2
			334 00 54.52	154 1 4.66	Buck Island Chute	1,028.4
Williams	34 52 36.22	90 17 31.83	218 40 31.62	38 41 25.98	Star Landing	3,860.4
			54 20 40.70	234 20 16.86	Buck Island Chute	1,303.1
Buck Island	34 51 37.17	90 18 55.16	196 59 58.56	17 00 12.22	Horseshoe Lake	2,075
			224 55 39.36	44 56 3.16	Buck Island Chute	1,497.1
Buck Island Chute	34 52 11.57	90 18 13.53	86 17 41.56	266 17 5.25	Porter Lake	1,616.1
Porter Lake	34 52 8.18	90 19 17.04	329 49 18.25	149 49 30.75	Buck Island	1,105.1
			58 17 19.75	238 16 43.24	Hackler	1,906.8
Hackler	34 51 35.65	90 20 20.91	268 45 12.74	88 46 1.75	Buck Island	2,178.2
			345 6 55.54	165 7 3.50	Bennett	1,463.8
Bennett	34 50 49.74	90 20 6.11	230 56 31.30	50 57 11.84	Buck Island	2,320.3
Bowie's Point	34 50 45.81	90 21 31.44	266 48 9.14	86 48 57.90	Bennett	2,170.9
			229 23 28.74	49 24 9.04	Hackler	2,359.4
			162 54 17.23	342 54 9.33	Cottonwood	1,194.2
Cottonwood	34 51 22.86	90 21 45.26	259 34 13.13	79 35 1.34	Hackler	2,178.2
			50 12 15.63	230 11 40.65	Polk	2,024.2
			83 25 56.83	263 24 42.83	Basket	3,310.7
Polk	34 50 40.81	90 22 46.48	265 22 6.35	85 22 49.23	Bowie's Point	1,912.6
Basket	34 51 10.55	90 23 54.75	297 51 9.53	117 51 48.54	Polk	1,961.3
			20 43 43.13	200 43 22.70	Sand Point	2,566.7
			60 39 59.83	240 38 56.43	Blues Point	3,233.6
Sand Point	34 49 52.64	90 24 30.51	240 40 18.70	60 41 18.12	Polk	3,030.8
			113 8 4.89	293 7 21.93	Blue's Point	2,077.7
Blue's Point	34 50 19.13	90 25 45.71	13 1 57.53	193 1 44.07	Commerce	2,655.1
			46 14 33.03	226 13 26.60	Peters	4,092.7
Commerce	34 48 55.18	90 26 9.27	234 47 15.17	54 48 11.57	Sand Point	3,071.4
			84 5 30.16	264 4 37.20	Peters	2,369.8
			30 51 09.15	210 50 25.07	Baldwin	3,828.1

Geographical positions from Mound City, Ark., to Helena, Ark.—Continued.

Station.	Latitude.	Longitude.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″		*Meters.*
Peters	34 48 47.25	90 27 42.03	352 36 15.60	172 36 24.47	Baldwin	3,067.8
			310 18 30.99	130 19 27.47	Clark	3,298.6
Baldwin	34 47 8.52	90 27 26.50	246 48 44.17	66 49 31.77	Clark	2,306.9
			309 54 6.06	129 55 14.98	Brinkley	4,062.4
			340 54 5.67	160 54 24.73	Ashley	2,598.7
Clark	34 47 37.99	90 26 3.07	344 43 42.97	164 44 6.53	Brinkley	3,663.2
			20 43 14.46	200 42 45.93	Ashley	3,594.3
Ashley	34 45 48.88	90 26 53.09	272 56 8.43	92 56 53.23	Brinkley	2,223.7
			4 42 21.23	184 42 16.09	Moon Lake	2,793.6
			43 53 10.33	223 52 43.97	Clack	1,696.1
Brinkley	34 45 45.18	90 25 25.75	42 32 58.21	222 32 8.29	Moon Lake	3,624
Moon Lake	34 44 18.52	90 27 2.10	148 46 38.96	328 46 17.47	Clack	1,826.8
			105 44 31.77	285 43 5.34	Carter	4,067.3
Clack	34 45 9.20	90 27 39.33	80 44 1.77	260 42 56.54	Carter	2,948.6
			106 23 41.57	286 22 8.39	Bordeaux Island	4,332.1
Carter	34 44 53.77	90 29 32.76	143 42 41.63	323 42 13.69	Bordeaux Island	2,165.6
			88 14 30.13	268 14 7.83	Bordeaux Chute	966.4
Bordeaux Island	34 45 48.85	90 30 22.77	351 43 05.79	171 43 11.43	Bordeaux Chute	1,745.9
			30 22 35.19	210 22 13.87	Favorite Chute	1,898.5
Bordeaux Chute	34 44 52.78	90 30 12.88	95 00 27.72	275 00 .77	Favorite Chute	1,267.
			35 17 35.32	215 17 20.35	Platon	1,158.1
Favorite Chute	34 44 56.19	90 31 .16	332 59 37.17	152 59 49.15	Platon	1,177.3
			30 32 37.37	210 32 8.71	Rogers	2,517.6
Platon	34 44 22.15	90 30 39.14	58 19 36.24	238 18 55.61	Rogers	2,131.6
			359 57 47.98	179 57 47.96	Alexander	2,095.8
Rogers	34 43 45.82	90 31 50.45	296 49 37.71	116 50 18.36	Alexander	2,004.6
			337 9 53.61	157 10 9.12	Walnut Bend	1,784.7
Alexander	34 43 16.01	90 30 39.08	57 6 21.56	237 5 56.42	Walnut Bend	1,337.6
Walnut Bend	34 42 52.44	90 31 28.23	294 58 55.12	114 59 57.65	Perry	3,682.5
			325 42 6.12	145 43 20.94	Hardin's Point	5,988.1
Alexander	....	....	320 31 16.25	140 31 53 65	Perry	2,698.3
Perry	34 42 10.17	90 29 33.42	351 18 44.03	171 18 56.34	Hardin's Point	3,845.6
			320 33 24.30	140 34 32.72	Frederick	4,817.3
Hardin's Point	34 40 13.21	90 29 11.78	272 39 32.94	92 40 29.02	Frederick	2,512.5
			348 17 53.14	168 18 .05	Wardell	1,525.5
Frederick	34 40 9.42	90 27 33.19	57 58 25.91	237 57 36.75	Wardell	2,596.9
			27 20 34.99	257 19 49.74	O. K	4,412.9
Wardell	34 39 24.73	90 28 59.63	356 04 33.65	176 4 37.54	O. K	2,549.3
			62 17 44.55	242 17 15.55	Battle Island	1,466.5
O. K	34 38 2.19	90 28 52.78	141 38 55.63	321 38 22.75	Battle Island	2,373.7
			118 1 54.12	298 00 28.50	Shoo-Fly	4,167.4
Battle Island	34 39 2.60	90.29 50.62	84 24 21.75	264 23 29.	Shoo-Fly	2,373.7
			119 11 30.25	299 10 55.79	Berry	1,767.6
Shoo-Fly	34 38 55.08	90 31 28.40	216 49 35.50	36 49 53.79	Berry	1,366.4
			165 26 35.30	345 26 23.68	Saint Francis	2,069.6
			130 41 18.88	310 40 6.86	Jackson	4,251.3
			78 14 32.07	258 13 8.40	Turner	3,828.7
Berry	34 39 30.58	90 30 51.23	124 10 21.89	304 9 51.96	Saint Francis	1,618.4
Saint Francis	34 40 .08	90 31 43.83	105 52 26.88	285 51 26.46	Jackson	2,810.8
Jackson	34 40 25.02	90 33 30.04	8 22 42.46	188 22 30.80	Turner	3,580.2
			40 46 51.66	220 45 55.02	Lotta	3,835.1
Turner	34 38 29.74	90 33 50.58	108 6 1.47	288 5 17.22	Lotta	2,665.
			54 17 11.15	234 16 11.88	Sterling	3,271.5
Lotta	34 38 50.76	90 35 8.41	14 45 38.22	194 45 23.18	Sterling	2,644.9
Sterling	34 37 27.75	90 35 34.87	309 21 43.78	129 22 37.46	Jack's Island	3,114.2
			340 1 41.48	160 1 55.56	Horner	1,848.3
Horner	34 36 31.37	90 35 10.09	277 38 00.66	97 38 40.26	Jack's Island	1,792.3
			314 48 38.86	134 49 16.32	Prairie Point	2,368.
Jack's Island	34 36 23.64	90 34 .36	183 39 59.16	3 40 4.72	Turner	3,893.5
			323 01 29.76	143 1 56.10	Buck-shot	1,965.1
			3 50 20.26	183 59 18.12	Prairie Point	1,434.7
Prairie	34 35 37.18	90 34 4.13	276 10 48.22	96 11 16.69	Buckshot	1,285.5
			355 56 50.12	175 56 54.11	Adams	2,533.5
Buckshot	34 35 32.69	90 33 13.97	316 58 59.78	136 59 32.57	Helena Island	2,157.9
			24 42 43.18	204 42 18.71	Adams	2,629.5
Helena Island	34 34 41.48	90 32 16.20	72 30 20.67	252 29 23.41	Adams	2,696.3
Adams	34 34 15.16	90 33 57.10				
W. Base	34 39 10.54	90 32 25.40	286 47 24.65	106 47 59.90	Shoo-Fly (east base)	1,648.3

A 3.

Geographical positions between Greenville, Miss., and Donaldsonville, La.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Hampton	30 5 12.13	373.7	90 53 7.46	199.8	....	....	....	....
Anderson	30 4 9.38	288.9	90 54 48.47	1,297.9	234 27 17.4	54 28 8	Hampton	3,324.8
Lemann	30 6 30.61	942.4	90 55 39.23	1,050.1	300 43 30.9	120 44 47	Hampton	4,727.8
					342 38 16.4	162 38 41.9	Anderson	4,556
Base, south end (Donaldsonville)	30 4 23.90	736	90 58 10.57	283.1	226 4 44.3	46 6 00.2	Lemann	5,625.5
					274 42 26.2	94 44 7.5	Anderson	5,431.5
Base, north end (Donaldsonville)	30 6 11.22	345.6	90 57 54.89	1,469.3	260 39 28.8	80 40 36.9	Lemann	3,680.9
					7 14 41.1	187 14 33.2	Donaldsonville, S. B	3,331.1
Tureaud	30 7 35.43	1,090.8	90 54 10.85	290.3	338 57 21	158 57 53	Hampton	4,727.5
					49 51 10	229 50 26	Lemann	3,095.4
Riverton	30 8 37.55	1,156.1	90 57 21.76	582.3	290 30 26	110 32 2	Tureaud	5,456.1
					324 54 55	144 55 47	Lemann	4,776.1
Burnside	30 9 52.19	1,606.9	90 55 55.82	1,493.4	326 17 6	146 17 59	Tureaud	5,061.8
					45 1 45	225 1 2	Riverton	3,251.5
Garnier Baggasse burner	30 8 23.15	712.8	90 52 32.56	872	....	....	....	....
Rapidan sugar-house chimney	30 4 38.26	1,178	90 52 24.02	643.1	131 52 21	311 52 00	Hampton	1,562.8
Colomb Baggasse burner	30 4 30.60	942.2	90 50 46.33	1,240.5	....	....	....	....
Union sugar-house chimney	30 6 40.08	1,234	90 54 14.94	400	82 38 2	262 37 20	Lemann	2,276.6
					326 18 5	146 18 39	Hampton	3,255.1
Anderson sugar house chimney	30 3 31.15	959.1	90 55 4.63	123.9	200 12 45	20 12 53	Anderson	1,253.6
Winchester sugar-house chimney	30 3 3.34	102.8	90 54 51.18	1,370.9	182 4 01	2 4 2	Anderson	2,034
Saint Victoria Baggasse burner	30 3 15.69	483	90 54 17.09	457.8	153 3 34	333 3 18	Anderson	1,853.8
New Hope sugar-house chimney	30 3 24.54	755.6	90 53 1.37	36.6	115 43 8	295 42 14	Anderson	3,183.3
Monlor sugar-house chimney	30 4 47.63	1,466.4	90 52 2.99	80	113 37 25	293 36 53	Hampton	1,885
Trist sugar-house chimney	30 4 30.21	930.2	90 53 1.65	44.1	173 6 8	353 6 5	Hampton	1,300.6
					77 22 41	257 21 47	Anderson	2,932.4
Lauderdale sugar-house chimney	30 4 28.03	863	90 55 10.87	291	313 45 55	133 46 6	Anderson	830.8
					168 37 20	348 37 5	Lemann	3,840.5
Salsbury sugar-house chimney	30 5 19.42	597.9	90 55 20.60	551.6	167 9 51	347 9 42	Lemann	2,247.4
					338 15 56	158 16 12	Anderson	2,322.3
Whitehall sugar-house chimney	30 4 42.21	1,299.6	90 53 37.38	1,000.8	220 59 23	40 59 38	Hampton	1,220.8
					170 27 34	350 27 17	Tureaud	5,408.5

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.*	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Leblanc Bagasse burner	30 4 59.64	1,836.2	90 55 41.57	1,113	317 25 32	137 25 59	Anderson	2,102.2
					181 16 51	1 16 52	Lemann	2,801
St. Mary's Church cross	30 5 17.96	553	90 54 17.33	461.1	21 33 45	201 33 29	Anderson	2,270.7
					135 33 49	315 33 7	Lemann	3,132.7
Brand sugar-house chimney	30 6 00.47	14.5	90 54 5.02	134.4	314 00 18	134 00 47	Hampton	2,141.9
					176 55 42	356 55 39	Tureaud	2,928.3
Scanlon sugar-house chimney	30 6 12.30	378.7	90 54 9.49	254.1	318 8 18	138 8 49	Hampton	2,487.7
					179 9 36	359 9 35	Tureaud	2,559.8
Houmas sugar-house chimney	30 7 27.27	839.6	90 54 26.23	702	238 28 30	58 28 37	Tureaud	460.9
					48 15 47	228 15 10	Lemann	2,621.1
Cofield sugar-house chimney	30 7 53.23	1,638.9	90 55 58.42	1,563.4	181 3 46	1 3 47	Burnside	3,662.6
					348 37 9	168 37 19	Lemann	2,595.9
Clark pump chimney	30 8 12.41	382.1	90 55 25.68	687.3	165 15 19	345 15 3	Burnside	3,176.4
					6 37 57	186 37 50	Lemann	3,156.3
Clark sugar-house chimney	30 8 37.55	1,136.1	90 55 27.52	736.4	161 42 47	341 42 32	Burnside	2,420.4
					4 36 17	184 36 11	Lemann	3,922.2
Brulé sugar-house chimney	30 8 31.54	971.1	90 53 15.42	412.6	120 3 18	300 1 57	Burnside	4,900.7
					40 42 35	220 42 7	Tureaud	2,278.2
Orange Grove sugar-house chimney	30 8 50.20	1,545.6	90 53 54	1,444.9	120 20 30	300 19 29	Burnside	3,779.5
					11 8 15	191 8 7	Tureaud	2,346.4
Donaldson sugar-house chimney	30 9 3.97	122.2	90 55 58.42	1,563.2	182 36 59	2 37 00	Burnside	1,485.7
					313 27 15	133 28 9	Tureaud	3,963.8
Riverton sugar-house chimney	30 8 57.16	1,759.8	90 56 51.38	1,374.8	221 14 11	41 14 40	Burnside	2,252.3
					53 25 48	233 25 33	Riverton	1,015.1
Conway sugar-house chimney	30 9 10.86	334.4	90 54 41.79	1,118.2	122 41 25	302 40 48	Burnside	2,355.8
					17 19 42	197 19 13	Lemann	5,109.2
Crescent	30 5 17.78	547.4	91 00 20.80	536.9	247 9 4.5	67 10 17.7	North Base	4,239.4
					295 25 56.6	115 27 1.9	South Base	3,802.1
Leblanc	30 7 15.14	466.1	91 00 14.10	377.4	297 49 36.4	117 50 46.2	West Base	4,214.6
					2 50 37.7	182 50 34.3	Crescent	8,617.9
Ayraud	30 5 44.77	1,378.4	91 2 27.88	746.4	232 9 00 1	52 10 7.2	Leblanc	4,535.8
					283 42 58.1	103 44 1.8	Crescent	3,502.9
Evan Hall	30 7 31.81	979.4	91 2 36.88	987.3	355 49 4.6	175 40 9.1	Ayraud	3,304.7
					277 39 34.1	97 39 45.8	Leblanc	3,850.5
Saint Martin	30 9 15.71	483.7	91 2 03.15	84.8	15 45 47.9	105 45 31	Evan Hall	3,824.1
					321 49 18.1	141 50 7.9	Leblanc	4,729.6

Texas	30 10 26.44	814	90 58 16.78	448.9	70 14 22.0	250 12 28.3	Saint Martin	6,436.8
					28 4 00.2	208 3 1.3	Leblanc	6,675.1
Southwood	30 18 26.81	825.4	91 3 4.90	130.9	305 45 31.9	125 47 56.8	Texas	9,499.7
					347 56 6	167 56 37.1	Saint Martin	7,006.5
Claiborne	30 11 58.70	1,807.2	91 4 12.19	326	213 32 58.7	33 33 32.5	Southwood	3,255.8
					325 27 58.6	145 29 3.5	Saint Martin	6,091.6
Dupuy	30 14 42.93	1,321.7	91 6 42.57	1,187.9	321 29 48.1	141 31 3.8	Claiborne	6,461.4
					291 55 14	111 57 3.6	Southwood	6,274.6
Ophelia	30 13 4.60	141.7	91 8 8.43	225.4	217 9 52.5	37 10 35.7	Dupuy	3,799.9
					287 47 20.4	107 49 19.3	Claiborne	6,636.5
Rome	30 6 46.50	1,431.6	91 00 56.81	1,520.6	117 31 2.7	297 30 12.5	Evan Hall	3,020.5
					232 21 47.8	52 22 9.2	Leblanc	1,443.8
Dichary	30 8 23.93	736.8	91 00 31.02	830.2	64 32 5.9	244 31 2.7	Evan Hall	3,731.5
					122 53 38.9	302 52 52.6	Saint Martin	2,935.9
Bowden	30 9 39.47	1,215.3	90 59 40.71	1,089.1	30 4 9.9	210 3 44.6	Dichary	2,687.4
					79 8 38.4	259 7 26.8	Saint Martin	3,881
Rescue	30 12 58.45	1,799.6	91 4 35.72	955.1	250 12 57	70 13 42.7	Southwood	2,580.9
					341 6 59.2	161 7 11	Claiborne	1,944.6
Maryland	30 12 33.13	1,020.1	91 6 15.49	414.2	253 42 27.3	73 43 17.5	Rescue	2,779.9
					287 48 59	107 50 1	Claiborne	3,464.2
Belle Grove	30 11 22.14	681.7	91 7 11.89	318	214 36 40.5	34 37 8.9	Maryland	2,656.1
					256 48 35.1	76 50 5.5	Claiborne	4,937.1
School	30 14 53.96	1,662	91 7 14.93	398.9	291 27 15	111 27 31.3	Dupuy	929.4
					23 1 13	203 00 46.1	Ophelia	3,659.2
Point Pleasant	30 15 22.95	706.6	91 6 51.73	1,382.7	348 45 43.8	168 45 48.4	Dupuy	1,256.2
					34 48 18.9	214 48 7.2	School	1,086.5
Monticello	30 15 38.53	1,186.3	91 6 25.64	685.2	55 28 45.2	235 28 32.1	Point Pleasant	846.5
					14 48 47.9	194 48 39.4	Dupuy	1,770.7
Golden Ridge	30 15 54.89	1,690	91 7 40.50	1,082.5	8 6 25.6	188 6 11.5	Ophelia	5,296.7
					325 2 47.3	145 3 16.5	Dupuy	2,703.4
Clement	30 15 59.78	1,840.5	91 9 47.90	1,280.2	272 31 18.5	92 32 22.6	Golden Ridge	3,408.7
					333 44 56.5	153 45 46.6	Ophelia	6,014.2
Ventress	30 16 50.81	1,564.3	91 8 24.25	647.9	54 54 9.2	234 53 27	Clement	2,732.8
					325 48 59.2	145 49 21.8	Golden Ridge	2,081.5
Anger	30 17 26.38	812.2	91 10 03.83	102.4	292 21 45.9	112 22 36.1	Ventress	2,877.6
					350 55 48.1	170 55 56.1	Clement	2,700.4
Evergreen	30 16 28.82	887.3	91 11 56.98	1,522.7	239 36 52.9	59 37 50.1	Anger	3,505.3
					284 31 6.6	104 32 11.8	Clement	3,564.1
Batture	30 17 6	184.7	91 12 00.05	1.3	355 53 44.9	175 53 46.4	Evergreen	1,147.8
					258 34 00.1	78 34 58.7	Anger	3,168.9
Gay	30 16 41.86	1,288.8	91 12 44.49	1,189	237 57 28.2	57 57 50.5	Batture	1,401
					287 33 1.1	107 33 24.9	Evergreen	1,331.8
Plaquemine	30 17 17.12	527.1	91 13 36.61	978.3	307 55 35.3	127 56 1.5	Gay	1,766
					277 33 1.8	97 33 50.4	Batture	2,603.1

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Point	30 18 5.54	170.5	91 13 24.99	667.7	11 45 54.8	191 45 48.8	Plaquemine	1,523
					337 12 42.9	157 13 3.2	Gay	2,794.7
Woodland	30 18 25.28	778.5	91 13 58.40	1,560.1	304 15 7.8	124 15 24.6	Point	1,080
					344 29 39.8	164 29 50.7	Plaquemine	2,178.2
Medora	30 19 7.26	223.5	91 12 35.95	960.3	59 36 1	239 35 19.3	Woodland	2,554.1
					34 35 5.8	214 34 40.9	Point	2,308.4
Conrad	30 18 47.15	1,451.8	91 11 14.38	384	105 52 20	285 51 38.7	Medora	2,265.5
					69 50 56.9	249 49 50.9	Point	3,717.4
Bailey	30 19 22.87	704.2	91 11 9.83	262.6	6 18 43.8	186 18 41.4	Conrad	1,106.7
					78 12 30.6	258 11 47	Medora	2,850.4
Bend	30 19 26.44	814.1	91 9 37.69	1,006.8	87 26 53.5	267 26 6.9	Bailey	2,463.9
					64 54 33.8	244 53 45	Conrad	2,852.5
Manchac	30 18 59.06	1,818.5	91 8 51.13	1,365.6	124 8 3.2	304 7 39.6	Bend	1,502.9
					84 32 14.9	264 31 2.5	Conrad	3,844.9
Australia	30 20 9.88	304.2	91 9 36.29	969.3	331 2 39	151 3 1.7	Manchac	2,492.1
					1 36 25.9	181 36 25.1	Bend	1,337.9
Chatworth	30 20 41.01	1,262.8	91 9 2.23	59.5	43 30 35.1	223 30 17.8	Australia	1,321.6
					354 36 19.2	174 36 24.7	Manchac	3,153.1
Lopez	30 21 2.41	74.2	91 11 36.36	970.9	279 5 5.6	99 6 23.3	Chatworth	4,169
					296 45 28.8	116 46 29.2	Australia	3,591.8
Woods	30 20 24.97	768.9	91 10 49.80	1,330	132 51 14.8	312 49 51.8	Lopez	1,695.8
					260 14 17.3	80 15 11.6	Chatworth	2,915.3
Martin	30 20 21.73	669.1	91 12 11.45	305.8	216 47 59.2	36 48 16.8	Lopez	1,564.5
					275 1 14.2	95 2 32.4	Australia	4,160.4
Cottage	30 21 15.31	471.4	91 13 24.29	648.6	310 17 40.1	130 18 16.7	Martin	2,551
					277 50 20.8	97 51 15.1	Lopez	2,909.8
Hicky	30 20 45.69	1,406.9	91 14 33.64	898.3	243 46 33.9	63 47 8.8	Cottage	2,064.6
					280 58 59.8	101 00 11.5	Martin	3,868.9
Missouri	30 22 19.99	615.5	91 14 33.54	893.5	8 11.2	180 8 11.1	Hickey	2,903.9
					317 7 12.6	137 7 47.5	Cottage	2,717.8
Duncan	30 22 7.16	220.4	91 13 55.90	1,492.5	111 27 50.1	291 27 31.1	Missouri	1,079.9
					21 53 19.7	201 53 00.6	Hickey	2,703.0
Arlington	30 23 47.41	1,459.8	91 12 49.12	1,311	46 00 35.8	225 59 42.4	Missouri	3,875.4
					11 20 26.5	191 20 8.6	Cottage	4,776.9
Cinclare	30 23 45.79	1,410	91 13 36.63	977.6	267 44 44.5	87 45 8.4	Arlington	1,209.4
					29 54 17.2	209 53 48.3	Missouri	3,047.8

Boulieu	30 25 19.51	600.7	91 12 39.58	1,054.9	27 50 33	207 50 4	Cinclare	3,203.7
					5 9 20.1	185 9 15.2	Arlington	2,847.6
Base, south end (Baton Rouge)	30 25 9.43	290.4	91 11 42.15	1,124.8	101 37 59.5	281 37 30.4	Boulieu	1,562.6
					85 17 37.9	215 17 8.9	Arlington	3,094.1
Limerick	30 26 9.88	304.2	91 12 12.40	330.9	336 33 4.3	156 33 19.5	South Base	2,029.2
					25 1 10.4	205 00 56.6	Boulieu	1,711.7
Base, north end (Baton Rouge)	30 25 59.92	1,845	91 11 24.72	659.5	103 33 37.3	283 33 13.1	Limerick	1,308.9
					16 39 14.8	196 39 5.9	South Base	1,622.895
Baton Rouge	30 26 19	585	91 11 26.42	704.9	355 34 32.4	175 34 33.2	North Base	589.4
					77 6 36.5	257 6 13.1	Limerick	1,258.6
Ferry	30 27 10.10	311	91 12 1.52	40.5	329 14 7.4	149 14 25.1	Baton Rouge	1,831.2
					8 53 37.7	188 53 32.1	Limerick	1,877
Baton Rouge Barracks astronomical azimuth station	30 27 28.35	1,872.9	91 11 24.43	651.7	60 24 24.5	240 24 5.6	Ferry	1,138
					1 25 16.6	181 25 15.5	Baton Rouge	2,136.2
Baton Rouge astronomical and longitudinal station	30 27 18.02	554.8	91 11 17.86	476.4	88 07 21.6	268 7 18.8	Pole	148.77
Pole	30 27 17.86	549.8	91 11 23.43	625	175 16 18	355 16 17.5	Barracks	324.1
					76 45 59.5	256 45 40.1	Ferry	1,044
Hermitage sugar-house chimney	30 6 59.43	1,829.7	90 57 48.23	1,291	6 50 55	186 50 52	North Base	1,495.3
					52 33 01	232 31 45	Crescent	5,146.4
Donaldsonville Catholic Church, east tower	30 6 18.05	555.7	90 58 58.25	1,559.5	130 53 13	310 52 35	Leblanc	2,685.6
					340 1 57	160 2 21	South Base	3,739.5
Wallace sugar-house chimney	30 5 39.89	1,228.1	90 57 58.33	1,561.6	185 27 38	5 27 40	North Base	969
					79 53 26	259 52 15	Crescent	3,875.2
Stella sugar-house chimney	30 5 37.09	1,142	90 57 29.10	779.1	82 38 40	262 37 14	Crescent	4,636
					124 21 40	304 20 17	Leblanc	5,350.6
Dugas sugar-house, east chimney	30 5 55.55	1,710.2	90 58 11.01	294.7	221 48 50	41 48 58	North Base	647.5
					71 30 31	251 29 26	Crescent	3,664.7
Crescent sugar-house chimney	30 4 39.01	1,201.1	91 1 17.43	466.6	158 12 49	338 12 9	Evan Hall	5,730.4
					231 47 11	51 47 39	Crescent	1,930
Lemann sugar-house chimney	30 5 49.57	1,526.2	90 59 1.67	44.7	65 12 34	245 11 54	Crescent	2,834.2
					143 39 2	323 38 26	Leblanc	3,271.3
Ice-factory chimney	30 6 16.71	514.4	90 58 30.70	821.8	58 23 40	238 22 45	Crescent	3,461.8
					123 1 26	303 00 34	Leblanc	3,301.3
Donaldsonville, cross on convent	30 6 14.36	442.1	90 59 5.47	146.4	49 11 15	229 10 37	Crescent	2,665.5
					135 31 34	315 31 00	Leblanc	2,622.5
Donaldsonville, cupola of Lemann's block	30 6 25.81	794.6	90 59 13.37	358	40 46 8	220 45 34	Crescent	2,765.5
					138 3 14	318 2 44	Leblanc	2,225
Evan Hall saw-mill chimney	30 7 18.64	573.9	91 2 8.51	227.8	286 59 2	107 1 9	North Base	7,100.2
					297 16 19	117 16 55	Rome	2,159.6
Leblanc sugar-house, south chimney	30 7 46.75	1,439.3	90 59 34.41	920.9	317 49 33	137 50 23	North Base	3,968.6
					47 30 31	227 30 11	Leblanc	1,441.1
Frances Gomez sugar-house chimney	30 5 33.27	1,024.4	91 1 31.75	850.1	284 5 31	104 6 7	Crescent	1,958.7
					103 15 25	283 14 57	Ayrand	1,544.3
Evan Hall sugar-house chimney	30 7 2.28	70.2	91 2 52.87	1,415.2	264 40 16	84 41 36	Leblanc	4,268.7
					344 20 14	164 20 27	Ayrand	2,478.7

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Donaldsonville Methodist Church	30 6 15.28	470.2	90 59 25.48	682.1	39 55 22	219 54 54	Crescent	2,308.6
					144 46 6	324 45 42	Leblanc	2,256.3
Donaldsonville Baptist Church	30 6 11.64	358.4	90 59 18.79	503.1	45 2 29	225 1 58	Crescent	2,846.7
					142 52 3	322 51 35	Leblanc	2,452.6
Souvenir sugar-house chimney	30 6 45.94	1,414.4	91 1 51.94	1,390.4	27 3 57	207 3 39	Ayrand	2,115.1
					139 34 40	319 34 18	Evan Hall	1,855.4
Gem sugar-house chimney (?)	30 8 42.08	1,295.6	91 00 2.69	72	53 37 36	233 37 22	Dichary	941.7
					198 24 27	18 24 38	Bowden	1,862
Bowden sugar-house chimney	30 9 36.64	1,128.1	90 59 1.07	28.6	82 28 47	262 27 16	Saint Martin	4,915
					217 41 22	37 41 44	Texas	1,938
McManner sugar-house chimney	30 7 42.49	1,308.2	91 2 40.30	1,078.5	249 44 56	69 46 1	Dichary	3,687.9
					344 27 22	164 27 24	Evan Hall	341.4
McManner saw-mill chimney	30 7 44.22	1,361.5	91 2 11.55	309.1	311 36 36	131 37 14	Rome	2,676.2
					60 35 27	240 35 14	Evan Hall	778.3
Canty saw-mill chimney	30 7 39.98	1,230.9	91 1 31.59	845.5	330 30 58	150 31 16	Rome	1,891.8
					23 1 12	203 00 44	Ayrand	3,854.5
Palo Alto sugar-house chimney	30 5 37.30	1,148.4	91 2 23.93	640.6	155 19 31	335.19 29	Ayrand	253.3
					174 23 9	354 23 2	Evan Hall	3,543.2
Burnside bagasse burner	30 8 34.94	1,074.8	91 2 2.71	72.5	25 12 6	205 11 49	Evan Hall	2,148.1
					179 28 8	359 8 8	Saint Martin	1,255.5
Adelard Landry sugar-house chimney	30 10 2.25	69.3	91 00 48.96	1,309.8	291 00 40	111 1 14	Bowden	1,956.3
					54 10 37	234 10 00	Saint Martin	2,448.0
R. O. Landry sugar-house chimney	30 8 56.24	1,731.5	91 1 36.25	970	31 58 40	211 58 9	Evan Hall	3,064.0
					129 47 26	309 47 12	Saint Martin	936.7
St. Ann's Chapel	30 9 6.78	208.7	90 50 42.17	1,128.3	182 13 8	2 13 9	Bowden	1,007.2
					94 10 37	274 9 26	Saint Martin	3,782.6
Ashland flag-staff	30 10 23.72	730.4	91 00 7.84	209.7	331 56 55	151 57 9	Bowden	1,543.9
					55 50 25	235 49 27	Saint Martin	3,728.8
Ashland sugar-house chimney	30 10 59.90	1,844.2	90 59 14.96	400.1	303 29 36	123 30 5	Texas	1,866.7
					15 33 1	195 32 48	Bowden	2,570.6
Mount Houmas sugar-house chimney	30 12 11.88	365.8	91 00 41.51	1,110.1	309 58 17	129 59 30	Texas	5,052.9
					102 54 41	282 52 43	Rescue	6,426.1
Waterloo sugar-house chimney	30 12 42.28	1,301.7	91 1 19.16	512.2	310 35 53	130 37 35	Texas	6,425.9
					87 50 3	267 56 34	Maryland	7,929.0
Cuba sugar-house chimney	30 11 4.48	138	91 2 5.35	143	358 58 54	178 58 55	Saint Martin	3,349.9
					116 12 37	296 11 33	Claiborne	3,780.8
Yale sugar-house chimney	30 10 46.66	1,436.5	91 1 47.86	1,280.2	8 18 38	188 18 30	Saint Martin	2,830.1
					119 53 26	299 52 14	Claiborne	4,452.9

Woodstock sugar-house chimney	30 10 28.12	865.8	91 1 20.51	548.7	27 6 16	207 5 55	Saint Martin	2,504.7
					121 16 48	301 15 22	Claiborne	5,373.5
Modeste sugar-house chimney	30 10 23.42	721.1	91 1 7.85	209.9	35 22 10	215 21 48	Saint Martin	2,556.5
					120 45 48	300 44 15	Claiborne	5,738.2
Home-place sugar-house chimney	30 9 26.63	819.9	91 00 42.41	1,134.6	81 9 22	261 8 41	Saint Martin	2,186.5
					129 51 10	309 49 25	Claiborne	7,309
Pelico sugar-house chimney	30 9 7.75	238.6	91 1 19.13	511.9	249 38 45	69 39 34	Bowden	2,808.8
					101 45 14	281 44 52	Saint Martin	1,202.9
Dichary sugar-house chimney	30 8 21.56	663.8	91 00 11.37	304.3	97 54 59	277 54 49	Dichary	531
					198 52 45	18 53 00	Bowden	2,535.3
Mount Houmas House, south gable	30 11 44.14	1,359	91 1 12.85	343.6	112 52 28	292 50 56	Rescue	5,868.6
					136 32 15	316 31 19	Southwood	4,356.6
Chatham sugar-house chimney	30 11 24.09	741.8	91 3 37.71	1,008.7	116 45 00	296 43 41	Maryland	4,725.7
					151 54 10	331 53 41	Rescue	3,294.1
Claiborne sugar-house chimney	30 11 50.01	1,539.7	91 4 33.92	907.1	178 41 46	358 41 45	Rescue	2,108
					245 17 11	65 17 22	Claiborne	640
Ohlivalla sugar-house chimney	30 10 41.37	1,273.7	91 7 35.26	943.1	211 47 33	81 48 13	Maryland	4,019.5
					246 18 54	66 20 36	Claiborne	5,931.4
Belle Grove sugar-house chimney	30 11 6.52	200.7	91 6 55.59	1,487	137 48 12	317 48 3	Belle Grove	649.3
					201 54 36	21 54 56	Maryland	2,874.5
Celeste sugar-house chimney	30 11 29.94	921.9	91 6 19.47	520.7	80 17 31	260 17 4	Belle Grove	1,422.8
					183 8 5	3 8 7	Maryland	1,948.9
Belle Grove store, east gable	30 11 21.67	667.2	91 7 11.85	317	175 49 51	355 49 51	Belle Grove	14.5
					256 38 38	76 40 8	Claiborne	4,939.3
Old Hickory sugar-house chimney	30 11 53.94	1,660.7	91 5 22.71	607.3	130 32 00	310 31 33	Maryland	1,857.4
					212 19 00	32 19 23	Rescue	2,850.7
Hard Times sugar-house chimney	30 13 15.64	481.5	91 5 13.91	871.8	297 23 16	117 23 35	Rescue	1,150.3
					325 7 42	145 8 13	Claiborne	3,887.5
Rescue sugar-house chimney	30 13 10.88	335	91 4 28.91	772.9	257 40 44	77 41 26	Southwood	2,299.8
					348 37 35	168 37 43	Claiborne	2,267.5
Revanue sugar-house chimney (?)	30 13 32.40	997.6	91 3 58.18	1,555.5	276 52 58	96 53 25	Southwood	1,434.9
					43 50 53	223 50 34	Rescue	1,449.4
Southwood sugar-house chimney	30 13 19.56	602.3	91 2 54.08	1,446	75 9 5	255 7 24	Maryland	5,573
					127 39 37	307 39 32	Southwood	365.6
Indian Camp sugar-house chimney	30 11 52.54	1,617.6	91 7 29.41	786.4	154 48 56	34 48 36	Ophelia	2,452.4
					246 23 19	366 24 47	Rescue	5,069.6
Arizona sugar-house, south chimney	30 13 16.99	523.1	91 5 3.88	103.7	264 33 57	84 34 57	Southwood	3,195.9
					307 10 33	127 10 47	Rescue	945.1
Arizona sugar-house north-chimney	30 13 17.46	537.6	91. 5 4.02	107.5	264 49 40	84 50 41	Southwood	3,198.5
					307 43 1	127 43 15	Rescue	956.9
River light	30 12 57.41	1,767.5	91 4 47.57	1,271.9	72 22 8	252 21 24	Maryland	2,467.4
					264 14 42	84 14 48	Rescue	818.4
Star sugar-house chimney	30 14 49.26	1,516.6	91 6 25.28	675.6	40 34 8	220 33 16	Ophelia	4,241.9
					145 43 24	325 43 11	Point Pleasant	1,255.6

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Palo Alto	30 14 10.26	315.9	91 8 4.73	126.6	245 23 12	65 23 53	Dupuy	2,416.4
					2 47 42	182 47 40	Ophelia	2,024.1
Willow Glen	30 16 14.30	440.3	91 7 2.23	59.6	318 23 36	138 23 54	Monticello	1,473
					349 55 59	169 56 4	Point Pleasant	1,605.8
St. Gabriel Church	30 15 19.86	611.5	91 6 24.33	650.3	23 13 24	203 13 15	Dupuy	1,237.1
					97 24 28	277 24 14	Point Pleasant	738.7
Bagatelle sugar-house chimney	30 14 32.32	995.2	91 6 22.29	595.7	121 4 45	301 4 35	Dupuy	633.1
					153 12 56	333 12 41	Point Pleasant	1,746.4
One-Hundred Mile sugar-house chimney	30 14 28.77	885.8	91 6 36.03	963.2	158 8 12	338 8 9	Dupuy	470
					165 52 34	345 52 26	Point Pleasant	1,720.4
Levert	30 15 52.79	1,625.3	91 7 23.58	630.1	285 48 46	105 49 15	Monticello	1,610.3
					317 9 19	137 9 35	Point Pleasant	1,252.9
Greenfield sugar-house chimney	30 16 1.09	33.6	91 10 15.40	411.6	186 42 47	6 42 53	Anger	2,644.4
					273 8 37	93 8 51	Clement	736
Evergreen sugar-house chimney	30 16 16.64	512.4	91 11 53.10	1,419.2	123 57 15	303 56 23	Plaquemine	3,335.1
					173 1 33	353 1 30	Batture	1,531.3
Iron chimney	30 16 4.30	132.4	91 10 40.64	1,086.3	131 50 6	311 49 26	Batture	2,848.3
					248 32 29	68 33 38	Ventress	2,916.7
Church near Evergreen	30 16 29.16	897.9	91 11 54.45	1,455.2	106 17 58	286 17 38	Gay	1,393.4
					239 11 55	59 12 51	Anger	3,441.7
Forlorn Hope sugar-house chimney	30 17 24.21	745.6	91 9 25.67	686	76 13 31	256 11 51	Gay	5,471.2
					82 16 14	262 14 56	Batture	4,163.8
Plaquemine Catholic Church spire	30 17 31.97	984.5	91 14 2.85	76.2	224 22 48	44 23 7	Point	1,446.4
					303 6 19	123 6 32	Plaquemine	837.1
Light-house (near Woodland)	30 18 26.28	809.2	91 13 55.02	1,470	239 8 35	59 9 15	Medora	2,460.8
					308 30 44	128 30 59	Point	1,025.6
McWilliams's house lightning-rod	30 19 8.34	256.8	91 12 33.79	902.7	287 5 21	107 6 1	Conrad	2,219.4
					35 17 4	215 16 38	Point	2,368.6
Small house chimney	30 18 48.66	1,498.4	91 9 19.62	524.2	247 10 47	67 11 1	Manchac	826
					157 28 6	337 27 57	Bend	1,259.8
Manchac sugar-house chimney	30 18 42.30	1,302.6	91 8 23.10	617.2	124 34 1	304 33 47	Manchac	909.6
					91 52 53	271 51 27	Conrad	4,578.9
Australia sugar-house chimney	30 19 57.03	1,756.2	91 9 30.35	810.7	158 9 1	338 8 58	Australia	426.4
					209 00 45	29 00 59	Chatworth	1,548.6
Light-house (near Chatworth)	30 20 24.40	751.4	91 8 36.96	987.8	74 14 38	254 14 03	Australia	1,046.2
					127 10 73	307 9 50	Chatworth	846.4

Rousan sugar-house chimney	30 20 30.97	953.7	91 8 5.19	198.0	23 26 46	203 26 23	Manchac	3,084.7
					75 3 39	255 2 53	Australia	2,518.5
Chatworth sugar-house chimney	30 20 53.56	1,649.4	91 8 36.12	964.6	6 29 27	186 29 19	Manchac	3,548.4
					61 00 34	241 00 21	Chatworth	797.2
Mulberry Grove sugar-house chimney	30 21 15.55	478.8	91 9 54.95	1,467.5	43 14 57	223 14 29	Woods	2,138
					346 9 8	166 9 17	Australia	2,082.5
Hollywood Bagasse chimney	30 21 15.40	474.2	91 10 38.58	1,030.3	10 55 29	190 55 23	Woods	1,581.5
					320 29 13	140 29 45	Australia	2,614.8
Touliet sugar-house chimney	30 20 25.26	777.9	91 11 44.48	1,188	81 25 49	261 25 35	Martin	728.4
					190 44 11	10 44 15	Lopez	1,164.5
Leperre sugar-house chimney	30 20 28.23	869.3	91 13 11.89	317.5	167 7 42	347 7 36	Cottage	1,487
					277 4 6	97 4 36	Martin	1,626.8
Light-house near Hicky (removed in April, 1880)	30 20 56.19	1,730.4	91 14 35.79	955.8	181 19 52	1 19 53	Missouri	2,581.1
					252 51 38	72 52 14	Cottage	1,908.1
Cottage sugar-house chimney	30 21 26.96	830.2	91 13 37.93	1,012.9	314 32 57	134 33 4	Cottage	511.3
					49 29 59	229 29 31	Hicky	1,956.6
Brulé Landing Church	30 23 9.92	305.4	91 14 9.27	247.5	241 38 49	61 39 10	Arlington	2,431.4
					349 32 00	169 32 7	Duncan	1,965.4
Cinclare stable lightning-rod	30 23 49.57	1,526.6	91 13 52.33	1,396.8	215 2 58	35 3 35	Boulieu	3,383.2
					285 31 38	105 31 46	Cinclare	435
Boulieu sugar-house chimney	30 25 28.09	865	91 12 49.23	1,313.7	287 47 29	107 48 3	South Base	1,880.2
					315 34 40	135 34 45	Boulieu	369.8
Vohn's sugar-house chimney	30 24 20.19	621.8	91 13 35.33	943	219 11 13	39 11 41	Boulieu	2,357
					1 52 18	181 52 17	Cinclare	1,059.7
Baton Rouge State University, pole on cupola	30 26 28.70	883.8	91 11 7.86	209.7	26 54 45	206 54 37	North base	994
					58 54 24	238 54 15	Baton Rouge	578.5
Baton Rouge Methodist Church spire	30 27 5.76	177.4	91 11 11.56	308.4	95 43 42	275 43 17	Ferry	1,339.5
					43 19 51	223 19 20	Limerick	2,365.5
Oaks sugar-house, south chimney	30 26 50.13	1,543.8	91 12 19.40	517.7	304 8 9	124 8 36	Baton Rouge	1,708
					351 25 29	171 25 33	Limerick	1,253.4
Baton Rouge State penitentiary, round brick chimney	30 27 4.21	129.7	91 10 55.59	1,483	95 53 28	275 52 55	Ferry	1,768.5
					21 26 7	201 25 52	North Base	2,127
Limerick sugar-house, south chimney	30 26 6.64	204.4	91 12 21.91	584.7	248 30 18	68 30 23	Limerick	272.7
					17 56 56	197 56 47	Boulieu	1,525.4
Limerick sugar-house, north chimney	30 26 07.17	220.7	91 12 21.85	583	251 40 34	71 40 39	Limerick	265.6
					278 19 37	98 20 6	North Base	1,541
Gay's house lightning-rod	30 26 57.53	1,771.6	91 12 5.83	155.5	196 31 57	16 31 59	Ferry	403.7
					318 26 59	138 27 19	Baton Rouge	1,585.4
Baton Rouge State-House, northwest tower	30 26 51.56	1,587.8	91 11 20.29	541.8	174 25 55	354 25 53	Barracks	1,138.5
					117 26 28	297 26 7	Ferry	1,239.2
Baton Rouge Barracks, flag-staff	30 27 23.45	722.2	91 11 17.33	462.3	128 35 40	308 35 37	Barracks	242.3
					70 47 47	250 47 25	Ferry	1,248.5
Wick's sugar-house chimney	30 25 32.16	990.3	91 11 3.26	87	56 00 10	235 59 50	South Base	1,252
					81 23 4	261 22 15	Boulieu	2,598.6

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Chamberlain	30 28 36.84	1,134.2	91 12 39.84	1,062.4	316 20 57.9	136 21 36.1	Barracks	2,914.7
					339 3 14.8	159 3 34.1	Ferry	2,860.1
Anchorage	30 28 56.53	1,740.6	91 12 1.00	26.7	59 39 55.8	239 39 36.1	Chamberlain	1,200.3
					340 14 05	160 14 23.5	Barracks	2,885.3
Favrot	30 29 56.62	1,743.4	91 13 16.57	441.8	312 33 12	132 33 50.3	Anchorage	2,736
					338 15 34.6	158 15 53.2	Chamberlain	2,644.8
Poplar	30 29 21.20	652.8	91 13 52.09	1,389.0	220 58 22.2	40 58 40.2	Favrot	1,444.7
					305 19 39.2	125 20 15.8	Chamberlain	2,862.1
Belle Vale	30 30 15.85	488.0	91 14 57.85	1,542.3	338 48 52.2	133 49 25.6	Poplar	2,430.6
					282 21 36.4	102 22 27.8	Favrot	2,765.1
Swamp	30 30 56.46	1,738.4	91 14 56.65	1,510.2	1 27 41	181 27 40.4	Belle Vale	1,251
					304 37 2.4	124 37 53.2	Favrot	3,243.2
Belair sugar-house, west chimney	30 30 29.34	903.5	91 12 25.29	674.4	6 23 26	186 23 19	Chamberlain	3,485.9
					47 48 48	227 48 4	Poplar	3,124.1
Belmont sugar-house chimney	30 29 59.54	1,833.5	91 14 10.47	279.1	11 41 18	291 40 54	Belle Vale	1,359.8
					337 27 5	157 27 14	Poplar	1,278.1
Babina sugar-house chimney	30 29 48.08	1,480.6	91 15 36.50	973.3	230 19 11	50 19 31	Belle Vale	1,339.2
					206 46 26	26 46 46	Swamp	2,358.5
Anchorage sugar-house chimney	30 29 00.32	9.9	91 12 19.57	522.0	283 16 7	103 16 17	Anchorage	508.9
					36 47 5	216 46 55	Chamberlain	902.8
Belle Vale sugar-house chimney	30 30 15.11	465.3	91 14 50.12	1,336.4	96 18 2	276 17 58	Belle Vale	207.3
					172 12 46	352 12 43	Swamp	1,285.2
Poplar Grove sugar-house chimney	30 29 26.77	824.3	91 12 24.08	642.2	85 49 31	265 48 46	Poplar	2,353.4
					123 17 41	303 17 14	Favrot	1,674.5
St. Peter's and St. Paul's Church	30 30 16.74	515.5	91 15 11.93	318.1	274 11 31	94 11 38	Belle Vale	376.3
					198 24 52	18 25 00	Swamp	1,280.1
Hill	30 28 26.16	805.4	91 12 00.77	20.5	331 23 18	151 23 36	Barracks	2,026.8
					0 29 42	180 29 42	Ferry	2,842.2
Bayou	30 28 28.01	862.4	91 11 31.79	847.7	353 51 41	173 51 45	Barracks	1,846.8
					85 47 36	265 47 21	Hill	775.1
Knox	30 29 17.00	523.4	91 11 35.75	953.3	355 59 48	175 59 50	Bayou	1,512.4
					23 5 16	203 5 8	Hill	1,701.9
Von Pool	30 29 25.04	770.9	91 12 2.07	55.2	289 25 59	109 26 12	Knox	744.6
					358 53 52	178 53 53	Hill	1,813.7
Monte Sano	30 30 38.62	1,189.1	91 11 35.42	944.4	0 11 41	180 11 41	Knox	2,513.7
					17 24 50	197 24 37	Von Pool	2,974.8

Belair	30 30 33.81	1,041.0	91 12 7.55	201.3	260 10 18	80 10 34	Monte Sano	869.6
					356 2 54	176 2 57	Von Pool	2,122.6
Hard Times	30 31 13.33	410.5	91 12 32.88	876.6	330 58 25	150 58 38	Belair	1,391.9
					304 53 35	124 54 4	Monte Sano	1,868
Allsworth	30 31 27.02	831.9	91 11 53.21	1,418.4	342 20 29	162 20 38	......do	1,563.0
					68 16 11	248 15 51	Hard Times	1,138.5
Horner	30 31 22.65	697.4	91 13 21.13	563.4	266 42 44	86 43 29	Allsworth	2,347.9
					282 34 41	102 35 6	Hard Times	1,318.2
Viola	30 31 2.33	71.8	91 13 10.14	270.3	251 11 5	71 11 24	......do	1,049.7
					154 54 17	334 54 11	Horner	690.9
Coal-yard	30 31 5.84	179.9	91 14 9.49	253.0	248 7 18	68 7 43	......do	1,239.8
					273 54 6	93 54 36	Viola	1,586.1
Belmont	30 30 40.21	1,238.2	91 14 2.45	65.3	243 58 5	63 58 32	......do	1,552.2
					166 37 20	346 37 16	Coal-yard	811.2
Colwell	30 30 33.08	1,018.5	91 16 28.16	750.8	253 33 14.1	73 34 00.6	Swamp	2,543.84
					282 25 15.5	102 26 1.3	Belle Vale	2,465.85
Bar	30 30 54.46	1,676.0	91 16 25.59	682.3	268 30 19.8	88 31 5	Swamp	2,372.08
					5 56 20.7	185 56 19.4	Colwell	661.86
Chinn	30 31 20.65	635.8	91 17 28.83	768.6	205 33 30.8	115 34 2.9	Bar	1,869.22
					312 9 20.4	132 9 51.2	Colwell	2,182.48
Point	30 31 24.19	744.9	91 16 50.51	1,346.4	339 15 32.5	159 15 43.8	......do	1,682.81
					83 55 13.2	263 54 53.7	Chinn	1,027.61
Chamberlain	30 32 9.03	278.0	91 17 30.01	799.9	322 40 8.4	142 40 28.5	Point	1,736.64
					358 47 45.3	178 47 45.9	Chinn	1,490.14
Winter	30 32 4.12	126.9	91 16 30.43	811.1	23 31 6.1	203 30 55.9	Point	1,841.17
					95 26 28.7	275 25 58.4	Chamberlain	1,596.30
Devall	30 32 52.58	1,619.1	91 15 53.62	1,429.0	33 20 7.1	213 19 48.4	Winter	1,785.82
					62 26 51	242 26 2	Chamberlain	2,898.16
Thomas	30 32 31.95	983.8	91 15 36.48	972.3	59 13 9	239 12 41.6	Winter	1,674.06
					144 16 48.1	324 16 39.4	Devall	782.43
Springfield	30 33 54.83	1,688.3	91 15 2.51	66.9	19 31 59.7	199 31 42.4	Thomas	2,708.12
					35 23 52.4	215 23 26.4	Devall	2,351.70
Clarke	30 33 57.99	1,785.6	91 15 42.41	1,130.0	275 13 13.1	95 13 33.4	Springfield	1,067.82
					8 26 00.4	188 25 54.7	Devall	2,036.29
Last	30 34 42.00	1,293.3	91 16 00.57	15.2	313 11 18.7	133 11 48.3	Springfield	2,121.99
					340 21 17.7	160 21 26.9	Clark	1,438.94
Reynaud	30 34 17.51	539.1	91 16 5.26	140.1	189 24 34.3	9 24 36.7	Last	764.35
					314 38 18.9	134 38 30.5	Clark	855.51
Solitude	30 34 29.5	894.4	91 16 50.45	1,344.2	253 17 48.9	73 18 14.8	Last	1,387.70
					286 26 6.7	106 26 29.7	Reynaud	1,255.57
Riley	30 34 57.47	1,770.4	91 16 49.10	1,308.2	290 13 16.1	110 13 40.8	Last	1,378.15
					2 21 7.5	182 21 6.8	Solitude	875.93
Profit Island	30 34 56.93	1,752.9	91,17 50.14	1,335.8	269 24 51.1	89 25 22.2	Riley	1,626.32
					298 21 42.6	118 22 13	Solitude	1,807.30

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Lobdell	30 34 35.90	1,105.4	91 17 52.48	1,398.2	185 31 7.4	5 31 8.6	Profit Island	650.76
					277 16 4.2	97 16 35.8	Solitude	1,606.39
Glennon	30 35 16.58	510.5	91 18 48.90	1,305.2	291 5 57.4	111 6 27.3	Profit Island	1,080.73
					309 45 51	129 46 19.7	Lobdell	1,958.62
Gravel	30 35 30.46	937.9	91 18 6.96	185.3	336 31 34.1	156 31 42.7	Profit Island	1,125.60
					69 6 47.5	249 6 26.1	Glennon	1,108.38
Brown	30 36 26.05	802.0	91 18 8.19	218.1	358 54 26	178 54 26.6	Gravel	1,712.04
					26 56 18.6	206 55 57.8	Glennon	2,399.32
Kelson	30 36 45.92	1,413.9	91 18 44.50	1,187.5	302 15 17.7	122 15 36.2	Brown	1,146.76
					2 26 10.2	182 26 8	Glennon	2,753.54
Mount Pleasant	30 38 14.70	452.5	91 17 52.34	1,393.6	7 11 34	187 11 25.9	Brown	3,372.60
					26 58 55.1	206 58 28.5	Kelson	3,067.91
Wild Wood	30 38 18.60	572.7	91 18 21.21	564.7	278 51 17.3	98 51 32	Mount Pleasant	778.12
					12 18 45.7	192 18 33.8	Kelson	2,021.02
Port Manoir	30 39 50.66	1,559.9	91 17 58.96	1,560.3	356 35 5.9	176 35 0.3	Mount Pleasant	2,960.00
					11 48 18.7	191 48 7.4	Wild Wood	2,896.18
Slaughter	30 39 56.26	1,732.3	91 17 23.56	627.1	13 46 11.5	193 45 56.8	Mount Pleasant	3,219.94
					79 37 10.9	259 36 52.8	Port Manoir	958.16
Port Hudson	30 40 27.00	831.3	91 17 54.10	1,439.9	319 20 11.2	139 20 26.8	Slaughter	1,247.80
					6 35 38.6	186 35 36.1	Port Manoir	1,126.69
Long Wood	30 39 57.43	1,768.3	91 18 28.22	751.2	224 55 46.9	44 56 4.3	Port Hudson	1,286.32
					284 59 8.4	104 59 23.3	Port Manoir	806.50
Sandy Point	30 40 13.41	412.9	91 19 16.45	437.9	259 10 59.8	79 11 41.8	Port Hudson	2,231.77
					290 58 2.4	110 58 27	Long Wood	1,374.81
Big Cave	30 39 50.81	1,564.5	91 19 8.36	222.5	162 48 32.9	342 48 28.8	Sandy Point	728.32
					259 12 5.1	79 12 25.6	Long Wood	1,087.77
Van Winkle	30 40 2.06	63.4	91 20 23.82	634.0	258 58 8.1	78 58 42.5	Sandy Point	1,827.32
					279 46 29.7	99 47 8.2	Big Cave	2,038.54
Fancy Point	30 40 33.13	1,020.1	91 19 53.08	1,412.7	301 54 42.1	121 55 00.8	Sandy Point	1,148.09
					40 32 54.3	220 32 38.6	Van Winkle	1,250.07
Waterloo	30 41 18.90	584.7	91 20 57.75	1,536.8	309 21 36.8	129 22 9.8	Fancy Point	2,226.72
					339 7 43.1	159 8 00.4	Van Winkle	2,535.38
Shelton	30 41 32.96	1,014.9	91 20 30.05	709.7	331 53 20.6	151 53 45.5	Fancy Point	2,088.83
					59 44 34.6	239 41 20.5	Waterloo	838.68
Labry	30 42 43.71	1,346.0	91 21 14.69	390.8	331 28 39	151 24 1.8	Shelton	2,481.54
					350 11 48.7	170 11 57.4	Waterloo	2,647.53

Lebret	30 42 50.09	1,542.4	91 20 43.24	1,150.3	351 35 34.3	171 35 41	Shelton	2,400.98
					76 47 24.8	256 47 8.7	Labry	850.66
Porche	30 43 10.87	334.7	91 21 21.56	573.6	302 6 59.6	122 7 19.3	Lebret	1,203.80
					347 40 49.9	167 40 53.4	Labry	856.23
Powell	30 44 5.82	179.2	91 21 21.56	578.5	336 23 54	156 23 13.6	Lebret	2,545.14
					350 59 46.3	170 59 46.3	Porche	1,691.96
Taylor	30 43 39.89	1,228.3	91 21 33.21	883.4	340 51 51.4	160 51 57.4	Porche	945.66
					201 12 21.1	21 12 27.1	Powell	856.55
Thompson	30 44 31.96	984.1	91 22 4.28	113.8	305 18 49.2	125 19 11	do	1,392.76
					332 43 40.7	152 43 56.0	Taylor	1,804.21
Fort	30 44 46.30	1,425.6	91 21 44.36	1,179.7	334 3 9.2	154 3 20.9	Powell	1,386.44
					50 11 34.3	230 11 24.1	Thompson	689.68
Point Coupée Base, southeast end	30 44 55.65	1,713.5	91 22 32.22	858.8	282 44 44	102 45 8.5	Fort	1,305.03
					314 28 16.5	134 28 30.8	Thompson	1,041.35
Alexander Creek	30 45 34.69	1,068.1	91 22 19.99	531.6	327 32 26.1	147 32 44.3	Fort	1,765.84
					15 8 9.5	195 8 3.2	Southeast Base	1,245.21
Point Coupée Base, northwest end	30 45 15.09	464.6	91 23 21.24	564.9	249 39 51.9	69 40 23.2	Alexander Creek	1,737.16
					294 38 59.7	114 39 24.8	Southeast Base	1,434.67
Taylor's sugar-house chimney	30 44 4.34	133.7	91 22 2.19	58.3	176 15 29	356 15 28	Thompson	852.6
					314 19 8	134 19 18	Taylor	1,077.6
Vignes sugar-house chimney	30 42 25.00	769.8	91 21 25.19	667.8	205 40 18	25 40 23	Labry	639.1
					235 15 22	55 15 43	Lebret	1,355.6
Waterloo Church	30 40 48.87	1,504.8	91 21 40.44	1,076.2	230 46 8	50 46 30	Waterloo	1,466.8
					279 37 00	99 37 55	Fancy Point	2,898.7
Waterloo store	30 41 50.56	1,556.8	91 21 06.12	216.1	298 8 38	118 8 57	Shelton	1,149.1
					344 9 24	164 9 29	Waterloo	1,010.7
Nina sugar-house chimney	30 40 57.64	1,774.8	91 21 4.74	126.1	195 48 5	15 48 9	do	683.2
					220 19 59	40 20 17	Shelton	1,426.6
Van Winkle B. B. (?)	30 39 20.57	633.4	91 20 43.16	1,149.1	173 55 6	353 54 59	Waterloo	3,667.2
					184 53 27	4 53 34	Shelton	4,091.6
Lieux sawmill	30 41 31.87	981.3	91 21 5.07	134.9	267 55 58	87 56 16	do	932.7
					338 20 34	158 20 55	Van Winkle	2,975.4
Elevator	30 40 19.62	604.1	91 17 21.84	581.4	47 56 5	227 55 46	Port Manoir	1,331
					104 50 27	284 50 11	Port Hudson	888.3
Port Hudson sawmill	30 40 36.66	1,128.8	91 17 20.56	547.2	17 29 10	197 28 27	Kelson	7,448.7
					20 48 10	200 47 39	Wild Wood	4,546.5
Wild Wood sawmill	30 38 15.63	481.0	91 18 23.75	685.6	232 49 47	52 49 49	do	151.9
					271 47 55	91 48 12	Mount Pleasant	890.2
Mount Pleasant Landing	30 38 32.16	990.5	91 17 45.62	1,214.6	18 25 25	198 25 22	do	506.5
					66 13 28	246 13 10	Wild Wood	1,035.8
Mount Pleasant gin	30 38 33.64	1,035.8	91 17 38.13	1,015.3	32 58 49	212 58 42	Mount Pleasant	694.9
					68 00 58	248 00 36	Wild Wood	1,237.9
Mount Pleasant stable (?)	30 38 33.40	1,028.4	91 17 30.79	819.7	44 55 28	224 55 17	Mount Pleasant	812.7
					71 15 32	251 15 6	Wild Wood	1,417.9

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Brown stable	30 36 36.95	1,187.8	91 17 49.82	1,326.9	55 33 10	235 33 1	Brown	593.5
					100 43 31	280 43 3	Kelson	1,484.8
Kelson sugar-house chimney	30 37 24.48	754.0	91 18 53.07	1,413.3	206 58 45	26 59 1	Wild Wood	1,870.2
					349 13 49	169 13 58	Kelson	1,208.4
Winter sugar-house chimney	30 36 43.60	1,342.6	91 19 02.95	78.6	261 40 28	81 40 37	......do	494.3
					290 19 23	110 19 51	Brown	1,555.7
Barrow sugar-house chimney	30 36 1.63	50.2	91 19 10.26	273.3	245 32 6	65 32 38	......do	1,816.4
					290 38 16	119 38 48	Gravel	1,940.2
Glennon sugar house chimney	30 34 52.92	1,629.5	91 19 06.32	168.3	212 22 8	32 22 12	Glennon	862.8
					233 49 55	53 50 25	Gravel	1,959
Randolph sugar-house chimney	30 35 24.28	747.6	91 19 16.57	441.4	264 8 15	84 8 50	......do	1,864.4
					287 52 41	107 52 55	Glennon	772.2
Hereford sugar-house chimney	30 34 16.74	515.4	91 18 27.54	733.9	193 34 24	13 34 34	Gravel	2,335.5
					218 50 9	38 50 28	Profit Island	1,589.2
Negro church or school	30 35 14.20	437.3	91 18 59.80	1,593.1	285 59 9	105 59 44	......do	1,930.8
					303 19 37	123 20 11	Lobdell	2,147
Clark sugar-house chimney	30 33 14.51	446.8	91 17 28.76	766.5	1 53	180 1 53	Chinn	3,506.2
					56 39	180 56 38	Chamberlain	2,016.6
Colwell sugar-house chimney	30 30 24.38	750.7	91 16 17.06	454.9	132 9 47	312 9 11	Chinn	2,581.5
					166 12 14	346 12 10	Bar	953.6
Base, east end (Vidalia)	31 33 42.59	1,311.6	91 25 18.00	474.6				
Base, west end (Vidalia)	31 35 01.020	31.4	91 26 24.010	633.1	324 13 2.4	144 13 37	East Base	2,977.272
Arnolia	31 33 33.145	1,020.9	91 26 41.285	1,088.8	189 33 12	9 33 21	West Base	2,744.5
					262 26 52.9	82 27 36.5	East Base	2,215.7
Lookout	31 33 12.153	374.3	91 25 10.763	283.9	105 9 29.1	285 8 41.7	Arnolia	2,473.4
					168 29 26	348 29 22.2	East Base	936.7
Cartharge	31 31 59.571	1,834.7	91 27 29.543	779.3	203 49 36.8	23 50 2	Arnolia	3,150.5
					238 34 46	58 35 58.6	Lookout	4,280.3
Whitehall	31 32 23.444	722	91 28 31.192	822.8	238 28 17.9	58 29 15.4	Arnolia	3,007.2
					294 19 24.2	114 19 56.4	Cartharge	1,784.8
Minor	31 31 1.785	55	91 29 2.113	55.8	107 58 7.4	17 58 23.6	Whitehall	2,044
					233 54 42.1	53 55 30.5	Cartharge	3,021.9
Natchez	31 31 25.991	800.5	91 30 20.202	533	238 23 18.1	58 24 15.1	Whitehall	3,370.6
					289 53 12.6	109 53 53.4	Minor	2,101.1
Conti	31 30 14.554	448.2	91 30 31.045	810.3	187 24 29.5	7 24 35.2	Natchez	2,218.7
					238 11 59.2	58 12 45.7	Minor	2,700.9

Lemley	31 30 00.352	10.8	91 29 38.554	1,017.4	107 31 47.2	287 31 19.8	Conti	1,452.0
					206 56 18	26 56 37	Minor	2,122.4
Moro	31 29 10.855	384.8	91 30 40.382	1,065.8	187 9 30.8	7 9 35.7	Conti	1,077.3
					220 56 35.5	40 57 7.8	Lemley	2,233
Ivanhoe	31 28 31.223	961.7	91 30 11.918	314.6	148 23 20.8	328 23 5.4	Moro	1,433.2
					197 47 00.7	17 47 18.1	Lemley	2,882.8
Warnicott	31 27 15.890	489.4	91 31 15.257	402.8	194 34 21.4	14 34 39.6	Moro	3,658.5
					215 46 34.1	35 47 7.2	Ivanhoe	2,859.9
Ford	31 27 30.245	931.6	91 30 16.297	430.8	74 08 57.7	254 8 26.9	Warnicott	1,618.2
					183 31 10.9	3 31 22.2	Ivanhoe	1,881.6
Saint Catharine	31 26 13.229	407.5	91 29 49.037	1,294.9	130 17 33.9	310 16 48.9	Warnicott	2,984.5
					163 7 14.0	343 7 00.4	Ford	2,478.8
Ashley	31 25 48.006	1,478.5	91 31 15.468	408.4	180 7 3.9	7 04	Warnicott	2,706.7
					251 11 58.6	71 12 38.7	Saint Catharine	2,411.1
Esperance	31 25 00.357	10.9	91 28 47.888	1,264.8	110 38 29.9	290 37 13	Ashley	4,164.9
					144 15 58.9	324 15 27	Saint Catharine	2,765
Page	31 25 40.849	1,258	91 28 47.632	1,257.8	18 36.5	180 18 36.4	Esperance	1 247.1
					121 35 42.8	301 35 10.8	Saint Catharine	1,908.7
Ellis Cliff	31 24 19.865	611.8	91 26 58.173	1,536.6	113 17 26.8	293 16 29.6	Esperance	3,155.1
					130 47 28.8	310 46 31.7	Page	3,818.4
Bourbon	31 23 20.039	617.1	91 28 48.516	1,281.9	180 18 26.7	18 27	Esperance	3,080.6
					237 41 50.9	57 42 48.4	Ellis Cliff	3,448.6
Pecan	31 24 21.736	669.4	91 30 30.917	816.7	270 34 19.2	90 36 10	....do	5,620.3
					305 4 30.7	125 5 24	Bourbon	3,305.9
Harper	31 23 24.827	764.6	91 29 55.309	1,461	151 46 43.5	331 46 25	Pecan	1,969.2
					274 46 15.7	94 46 50.5	Bourbon	1,770.9
Leonard	31 23 9.304	286.5	91 31 44.538	1,176.8	221 4 50.5	41 5 28.9	Pecan	2,959.6
					260 35 11.4	80 36 8.3	Harper	2,925.3
Fairview	31 24 27.657	851.8	91 31 54.010	1,426.6	274 44 35.1	94 45 18.4	Pecan	2,262.6
					354 4 43	174 4 47.9	Leonard	2,426
Rosenthal	31 22 48.931	1,507	91 34 11.85	313	230 7 51.4	50 9 8.2	Fairview	4,744.2
					260 49 55.5	80 51 12.2	Leonard	3,941.7
Glasscock	31 21 00.488	15	91 33 37.958	1,003.3	164 59 22.7	344 59 5.1	Rosenthal	3,457.8
					217 3 49.8	37 4 48.8	Leonard	4,972.3
Palmetto	31 21 00.150	4.0	91 32 00.022	0.6	90 13 53.8	270 13 2.0	Glasscock	2,588.7
					185 52 22.8	5 52 30.9	Leonard	3,998.4
Roseland	31 20 5.552	171	91 32 21.107	558	120 47 39	309 46 59	Glasscock	2,643.8
					198 20 00	18 20 11	Palmetto	1,771.7
Corena	31 20 16.816	517.9	91 31 18.574	491	78 9 8.5	258 8 36.0	Roseland	1,689.1
					140 37 23.9	320 37 4.3	Palmetto	1,726.9
Obers	31 18 49.540	1,525.6	91 31 42.210	1,116.1	156 17 11.3	336 16 51.1	Roseland	2,556.9
					193 5 11	13 5 23.3	Corena	2,759.6
Strothers	31 18 42.594	1,311.8	91 30 54.581	1,443.2	99 38 35.1	279 38 10.3	Obers	1,277.5
					167 40 13.8	347 40 1.3	Corena	2,970.3

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Winn	31 17 25.646	789.9	91 30 59.526	1,574.3	156 24 10.9	336 23 48.7	Obers	2,819.5
					183 9 29	3 9 31.6	Strothers	2,373.4
Frits	31 16 58.517	1,802.2	91 31 52.292	1,383.2	184 27 29.9	4 27 35.1	Obers	3,429.6
					239 5 21.3	59 5 48.7	Winn	1,626.6
McElroy	31 16 10.432	321.3	91 31 43.275	1,144.8	206 32 35	26 32 57.7	Winn	2,589.4
					170 51 3.3	350 50 58.6	Fritz	1,500
Cerro Gordo	31 15 47.236	1,454.8	91 32 51.365	1,359	215 26 26.8	35 26 57.9	..... do	2,094.7
					248 21 46.2	68 22 21.5	McElroy	1,937.8
Home Place	31 16 19.667	605.8	91 33 47.931	1,268	248 37 44	68 38 44	Frits	3,254.6
					305 42 56.3	125 43 25.7	Cerro Gordo	1,799.2
Allaway	31 15 43.248	1,332	91 34 18.929	500.7	216 10 10.4	36 10 26.5	Home Place	1,389.4
					266 57 29.3	86 58 14.7	Cerro Gordo	2,319.9
Wilds	31 16 30.130	927.9	91 35 7.853	207.7	278 39 36.8	98 40 18.3	Home Place	2,138.6
					318 7 23.0	138 7 40.3	Allaway	1,939
Jackson	31 16 2.508	77.3	91 35 31.661	837.5	216 30 51.2	36 31 3.6	Wilds	1,058.4
					287 7 42.2	107 8 20	Allaway	2,013.6
Point	31 16 9.553	294.2	91 36 25.051	662.6	252 45 19.6	72 45 59.7	Wilds	2,138.2
					278 43 47.3	98 44 15	Jackson	1,429
Bougère	31 16 42.706	1,315.3	91 36 58.092	1,536.7	277 33 28.4	97 34 25.6	Wilds	2,941.7
					319 25 54.5	139 26 11.7	Point	1,344
Cabin	31 15 32.765	1,009.2	91 38 12.692	335.8	222 29 28.6	42 30 7.3	Bougère	2,921.4
					248 17 49.4	68 18 45.3	Point	3,064.9
Pecan	31 14 54.474	1,677.7	91 38 4.354	115.1	169 24 12.2	349 24 7.9	Cabin	1,190.7
					228 38 33	48 39 24.5	Point	3,499.9
Kienstra	31 13 31.234	961.9	91 36 23.925	633.1	133 58 26.7	313 57 34.6	Pecan	3,692.6
					142 26 51	322 25 54.0	Cabin	4,721.5
Union Point	31 13 33.239	1,028.0	91 37 7.832	194	148 58 25.7	328 58 50.1	Pecan	2,921.7
					273 4 24.0	93 4 47.4	Kienstra	1,150.5
Peach Grove	31 11 35.340	1,088.3	91 35 49.768	1,318	150 31 27.8	330 30 47.6	Union Point	4,171
					165 47 59.7	345 47 22	Peach Grove	3,681.8
Loch Leven	31 10 15.203	468.2	91 36 45.011	1,207.0	185 25 50.1	5 26 1.3	Kienstra	6,064.4
					210 54 51.8	30 55 20.7	Peach Grove	2,870.8
Pullen	31 9 56.982	1,754.9	91 37 33.250	880.7	222 7 16.5	42 8 10.1	..... do	4,084.4
					246 1 12	66 1 36.9	Loch Leven	1,380.9
Island	31 9 21.984	677.1	91 36 52.888	1,400.7	135 11 4	315 13 48.1	Pullen	1,518.2
					186 42 20.1	6 42 23.0	Loch Leven	1,650.3

Black Hawk	31 9 23.573	726	91 37 34.041	901.5	181 9 29.6	1 9 30.9	Pulleu	1,020.1
					272 34 8.2	92 34 24.5	Island	1,091.1
Ballamagan	31 6 46.761	1,440	91 36 45.055	1,198.7	164 57 48.6	344 57 18.3	Black Hawk	5,000.6
					177 30 54.8	357 30 50.7	Island	4,784.8
Stamp	31 6 49.740	1,531.6	91 36 00.201	5.3	85 35 26.8	265 35 8.1	Ballamagan	1,192.1
					163 25 38	343 25 5.8	Island	4,892
Coochee	31 5 42.177	1,298.9	91 36 23.841	631.9	164 13 5.7	344 12 54.7	Ballamagan	2,066.9
					196 45 16.1	16 45 28.3	Stamp	2,173
Bartlett	31 5 32.797	1,010.1	91 35 33.218	880.2	102 9 7.7	282 8 41.6	Coochee	1,372.6
					163 12 23.2	343 12 9.8	Stamp	2,475.1
Point Breeze	31 4 15.822	487.2	91 33 45.781	1,213.6	122 25 2.8	302 23 41.2	Cochee	4,962.4
					129 47 1.5	309 46 6	Bartlett	3,705.3
Block House Hill	31 4 46.865	1,443.2	91 32 54,623	1,447.7	54 49 17.6	234 48 51.2	Point Breeze	1,659.8
					108 38 36.7	288 35 14.8	Bartlett	4,435.2
Rock Hill	31 2 09.861	303.6	91 33 20.326	539	170 7 53	350 7 39.9	Point Breeze	3,937.4
					188 1 14.8	8 1 28.	Block House Hill	4,882.9
Lum's Point Base, southwest end astronomical station	31 2 29.113	896.6	91 35 17.067	453.1	221 40 12.7	41 41 26.2	do	5,680.1
					280 49 52.2	100 50 52.4	Rock Hill	3,152.6
Lum's Point Base, northeast end	31 3 13.738	423.1	91 34 26.424	700.5	318 17 40.4	138 18 14.5	Rock Hill	2,634.7
					44 21 10.5	224 20 44.4	Southwest Base	1,921.817
Lum	31 2 52.850	1,627.6	91 34 44.811	1,188.2	211 28 59.1	31 29 29.6	Point Breeze	2,996.4
					300 34 26.7	120 35 10.3	Rock Hill	2,602.3
Tarbert	31 00 21.361	657.8	91 35 59.965	1,590.7	203 7 43.5	23 8 22.2	Lum	5,078.3
					231 42 36.1	51 43 58.4	Rock Hill	5,393.8
Ker's Point	31 00 49.324	1,518.8	91 36 47.881	1,270	220 37 13.3	40 38 16.7	Lum'	5,012.5
					304 0 48.0	124 7 13.3	Tarbert	1,535.3
Tregar	31 00 15.265	470.1	91 37 32.290	856.6	228 18 57.5	49 19 20.4	Ker's Point	1,577.3
					265 36 36	85 37 23.5	Tarbert	2,456.4
Eastman	30 58 28.864	888.8	91 38 37.939	1,008.7	207 50 21.5	27 59 55.3	Tregar	3,710.9
					230 24 46.4	50 26 7.7	Tarbert	5,437.8
Red River	30 58 50.280	1,548.5	91 39 8.546	226.8	224 17 27.3	44 18 16.9	Tregar	3,656.7
					309 4 28.9	129 4 44.7	Eastman	1,046.2
Angola	30 57 31.140	959	91 39 1.926	51.1	175 52 41.2	355 52 37.7	Red River	2,443.5
					199 42 6.1	19 42 18.4	Eastman	1,888.2
Kingsbury	30 57 27.872	858.4	91 39 45.243	1,200.8	200 59 20.3	20 59 48.2	Red River	2,718.3
					264 59 37.5	84 59 50.9	Angola	1,154.1
Hog Point	30 55 36.152	1,113.4	91 38 42.012	1,115.5	153 59 55.1	333 59 22.6	Kingsbury	3,828.1
					171 30 39.3	351 30 29.1	Angola	3,560.4
Acklin	30 56 5.523	170.1	91 38 10.813	287	42 28 50	222 28 43	Hog Point	1,226.5
					135 20 27.8	315 19 39.2	Kingsbury	3,565.7
Miles Point	30 55 12.251	377.2	91 37 29.082	772.1	110 49 4.9	290 48 27.4	Hog Point	2,071.5
					145 58 12.7	325 57 51.2	Acklin	1,979.6
Cut Off	30 55 32.442	999.1	91 37 10.204	270.8	38 52 20.6	218 52 10.9	Miles Point	738.7
					122 20 34.1	302 20 2.9	Acklin	1,904.5

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Old River	30 54 48.887	1,505.4	91 36 29.975	795.9	114 38 4.3	294 37 33.9	Miles Point	1,726.5
					141 28 20.8	321 28 00.1	Cut Off	1,714.7
Cheatham	30 55 19.372	596.5	91 36 9.667	256.6	29 52 21.5	209 52 14.1	Old River	1,082.7
					104 3 51	284 3 19.9	Cut Off	1,656.9
Saint Bernard	30 55 3.431	105.7	91 34 9.186	243.9	83 10 39.7	263 0 27.4	Old River	3,765.1
					98 44 00.3	278 42 58.4	Cheatham	2,236.4
Rowe	30 55 30.095	926.9	91 34 4.477	118.9	8 39 26.3	188 39 23.9	Saint Bernard	830.6
					84 20 7.1	264 19 2.8	Cheatham	3,340.2
Letherman	30 54 35.692	1,099.3	91 33 5.175	137.5	116 41 16	296 40 43.1	Saint Bernard	1,902.3
					136 46 48.2	316 46 17.7	Rowe	2,299.2
Como	30 54 30.037	925	91 31 53.172	1,411.9	95 12 34.7	275 11 57.7	Letherman	1,919.9
					117 57 17.6	297 56 10.1	Rowe	3,946.7
Stump	30 53 59.068	1,819	91 32 25.284	671.5	136 47 49.7	316 47 29.2	Letherman	1,547.3
					221 47 56.8	41 48 13.3	Como	1,270.3
Wade	30 52 39.770	1,224.8	91 31 13.56	360.1	142 2 51.9	322 2 15.1	Stump	3,097.2
					162 47 19.4	342 46 59.1	Como	3,555.9
Stevenson	30 52 32.038	986.7	91 31 41.39	1,099.4	156 20 39.9	336 29 17.4	Stump	2,922.7
					252 8 35.2	72 8 49.5	Wade	776.7
Douglas	30 51 19.844	611	91 31 42.774	1,136.5	180 56 50	56 50.7	Stevenson	2,223.5
					197 29 54	17 30 9	Wade	2,580.8
Brandon	30 50 59.611	1,835.8	91 31 7.407	196.8	123 32 57	303 32 38.9	Douglas	1,127.5
					176 58 00.8	356 57 57.6	Wade	3,088.8
Cotton	30 49 7.718	237.7	91 31 51.781	1,376.3	183 21 57.1	3 22 1.7	Douglas	4,075.9
					198 53 19.2	18 53 41.0	Brandon	3,642
Tunica Island	30 49 18.491	569.3	91 31 14.576	387.5	71 27 21.6	251 27 2.5	Cotton	1,043
					183 30 1	3 30 4.7	Brandon	3,119.9
Keller	30 47 52.998	1,632.1	91 31 21.613	574.5	160 47 18.1	340 47 2.7	Cotton	2,436.8
					184 3 47.6	4 3 51.2	Tunica Island	2,630.4
Raccourci Point	30 47 58.123	1,789.9	91 32 00.931	24.7	186 28 26.8	6 28 31.5	Cotton	2,157
					278 35 00.1	98 35 20.2	Keller	1,057.1
Bougeoir	30 47 15.112	465.4	91 32 24.978	664	205 45 50.3	25 46 2.6	Raccourci Point	1,470.8
					235 17 20.8	55 17 59.2	Keller	2,040.2
Shaw	30 47 37.584	1,157.4	91 32 38.514	1,023.9	332 31 21.2	152 31 28.1	Bougeoir	750
					237 39 40.1	57 39 59.3	Raccourci Point	1,182.5
Schultz	30 47 12.330	379.6	91 33 36.529	971.3	243 14 23.3	63 14 53	Shaw	1,727.4
					207 24 59.5	27 25 36.1	Bougeoir	1,904.8

Rews Ditch	30 47 41.247	1,270.3	91 33 44.223	1,175.5	273 41 23.4	93 41 57	Shaw	1,750.0
					347 3 51.3	167 3 55.3	Shultz	913.7
New Texas	30 46 54.017	1,663.6	91 35 13.490	359	238 29 48.0	58 30 34.6	Rews Ditch	2,783.8
					207 39 20.2	77 40 9.8	Schultz	2,630.3
Neal	30 46 33.438	1,020.7	91 34 41.994	1,116.7	127 06 32.8	307 06 16.7	New Texas	1,050.4
					216 20 5.6	36 20 35.2	Rew's ditch	2,592.3
Vignes	30 45 10.064	309.8	91 35 26.432	703.1	186 07 53.3	6 07 59.9	New Texas	3,219.7
					204 42 47.9	24 43 10.6	Neal	2,826.4
Leonard	30 45 12.477	384.3	91 34 55.455	1,474.8	84 50 51.7	264 50 35.9	Vignes	827.3
					188 10 11.8	8 10 18.7	Neal	2,518.7
Morganza	30 44 11.358	349.7	91 34 40.125	1,227	149 19 54.4	329 10 33.8	Vignes	2,101.8
					172 29 21.4	352 29 16.6	Leonard	1,898.4
Cat Island	30 44 26.684	760.2	91 33 57.443	1,528.1	72 25 13.1	252 24 48.2	Morganza	1,858.5
					133 38 56.5	313 38 26.8	Leonard	2,182.4
Bergeron	30 43 44.636	1,374.6	91 33 42.090	1,120	115 47 29.3	295 46 56.6	Morganza	1,891.7
					161 41 18.4	341 41 10.6	Cat Island	1,299.1
McCallum's Point	30 44 10.059	309.7	91 35 46.402	1,234.4	75 44 13.2	255 43 14.1	Bergeron	3,175.9
					97 22 18	277 21 11.1	Cat Island	3,514.9
Fisher	30 44 37.298	1,148.5	91 31 39.829	1,059.4	11 46 35.8	191 46 32.4	McCallum's Point	856.9
					102 17 29	282 16 37	Cat Island	3,681.2
Hopkins	30 43 50.928	1,568.3	91 30 4.097	125	102 17 29	282 16 37	McCallum's Point	2,769.0
					119 26 30.2	299 25 41	Fischer	2,905.7
Woodyard	30 44 12.220	376.3	91 28 47.200	1,255.6	72 21 44.4	252 21 4.8	Hopkins	2,163.4
					99 33 31.1	279 32 2.9	Fischer	4,656.6
Saint Maurice	30 43 44.873	1,381.9	91 28 42.966	1,143	94 54 26	274 53 44.2	Hopkins	2,182.3
					172 23 1.0	352 22 59.4	Woodyard	849.7
Bockel	30 44 32.882	1,012.6	91 27 12.909	343.3	58 19 35.5	238 18 49.5	Saint Maurice	2,815.2
					75 46 19.3	255 45 31.1	Woodyard	2,587.7
Red Store	30 44 3.492	107.6	91 27 00.303	8.1	78 9 3.4	258 8 11	Saint Maurice	2,790.7
					159 40 20.2	339 40 13.8	Bockel	965.2
Coulon	30 44 51.946	1,599.6	91 25 4.255	113.2	64 12 39.6	244 11 40.3	Red store	3,428.7
					80 16 32.2	260 15 26.5	Bockel	3,472.1
Willow Bar	30 45 20.079	618.3	91 25 21.347	567.8	332 18 45.8	152 18 54.5	Coulon	978.4
					63 54 47.7	243 53 50.7	Bockel	3,304.2
Magee	30 45 50.008	1,540	91 24 9.770	259.8	39 1 40.5	219 1 12.6	Coulon	2,301.5
					64 10 15.0	244 9 39.	Willow Bar	2,115
Bovard	30 45 6.405	197.3	91 23 58.076	1,514.7	75 48 32	255 47 58.2	Coulon	1,815.7
					166 57 36.6	346 57 30.7	Magee	1,378.3
Depot, astronomical station	30 45 52.739	1,624.2	91 23 18.456	490.7	36 26 54.3	216 26 34	Bovard	1,773.8
					86 28 34.7	266 28 8.6	Magee	1,367.2
Base, northwest end (Point Coupee)	30 45 8.636	265.9	91 23 24.030	639.1	85 39 51.3	265 39 33.9	Bovard	908.1
					186 13 42.5	6 13 45.4	Depot	1,366.2
Base, southeast end (Point Coupee)	30 44 49.203	1,515.2	91 22 35.008	931.1	114 39 24.9	294 38 59.8	Northwest base	1,434.672
					149 26 12.5	329 25 50.3	Depot	2,272.4

Geographical positions between Greenville, Miss., and Donaldsonvile, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Alexander Creek	30 45 28.236	869.6	91 22 22.784	606	15 8 10.1	195 8 3.9	Southeast base	1,245.2
					69 40 23.9	249 39 52.6	Northwest base	1,737.2
Crother's	31 28 26.02	801.3	91 31 44.18	110.3	263 22 48	83 23 15	Ivanhoe	1,388.8
					323 39 1	143 39 26	Ford	2,138
Shields	31 25 12.65	389.6	91 29 47.96	1,266.7	179 07 25	359 7 24	Saint Catharine	1,866
					241 24 5	61 24 36	Page	1,814.5
Surgett	31 24 20.02	616.5	91 28 48.14	1,271.5	180 18 8	18 8	Esperance	,,242.4
					270 5 8	90 6 5	Ellis Cliff	2,904.8
Butler's Bluff	31 25 20.27	624.2	91 25 42.88	1,132.3	40 54 56	220 54 17	Ellis Cliff	2,723.4
					97 24 46	277 23 10	Page	4,920.5
Rivers	31 23 39.08	1,203.6	91 33 19.45	513.7	236 27 23	56 28 7	Fairview	2,708
					290 4 41	110 5 30	Leonard	2,670.1
Ferguson	31 19 20.55	632.8	91 30 59.18	1,564.4	354 3 37	174 3 39	Strother's	1,175.4
					49 59 17	229 58 55	Ober's	1,485.5
Ville	31 18 1.73	53.3	91 30 53	1,401.4	138 31 55	318 31 29	Ober's	1,965
					178 05 55	358 5 54	Strother's	1,250.1
Gin-house stack near Crother's	31 28 10.96	522.4	91 31 21.33	563	220 25 20	40 26 14	Lemley	4,183
					256 31 5	76 31 41	Ivanhoe	1,884.3
Smoke-stack north of Crother's	31 28 43.86	1,350.7	91 31 8.80	232.2	284 32 4	104 32 34	Ivanhoe	1,551.2
					347 28 40	167 28 42	Crother's	562.8
Crother's house chimney	31 28 47.03	1,466.8	91 31 1.03	27.2	217 18 6	37 18 17	Moro	809.2
					7 34 27	187 34 20	Warnicott	2,850.4
Up-river dove-cote	31 28 47.87	1,474.2	91 30 57.94	1,529.2	292 52 45	112 53 9	Ivanhoe	1,818.5
					13 45 55	193 45 52	Crother's	692.6
Down-river dove-cote	31 28 46.92	1,444.9	91 30 58.17	1,535.1	291 36 5	111 36 29	Ivanhoe	1,313.1
					13 51 15	193 51 12	Crother's	602.8
Belfry north of Crother's	31 28 42.74	1,316.2	91 31 10.38	273.9	282 56 46	102 57 16	Ivanhoe	1,583.4
					2 45 20	182 45 26	Warnicott	2,678.1
Gin chimney near Warnicott	31 27 9.40	289.5	91 31 40.06	1,081.4	223 00 4	43 00 51	Ivanhoe	3,440
					253 58 12	73 58 56	Ford	2,325.5
Government light below Ashley	31 24 33.86	1,042.8	91 31 5.13	135.4	175 8 10	355 8 11	Warnicott	3,153.0
					238 53 15	58 53 54	Saint Catharine's	2,346.8
Government light near Shields	31 25 10.17	500.4	91 30 10.12	425.7	03 14 42	23 14 56	......do	1,812.1
					254 3 8	74 3 49	Page	2,430.5
Ashley gin chimney	31 20 11.13	342.8	91 31 29.94	790.5	268 35 58	88 30 51	Saint Catharine	2,065.5
					331 47 6	151 47 14	Ashley	808

Rosenthal's store, river end	31 23 51.54	1,587.2	91 33 24.82	655.6	258 32 32	78 34 8	Pecan	4,667.2
					296 8 30	116 9 22	Leonard	2,951.3
Deer Park gin chimney	31 24 29.28	901.7	91 33 2.67	70.5	271 34 30	91 35 6	Fairview	1,814.7
					320 1 51	140 2 32	Leonard	3,213.4
Rivers' gin chimney	31 24 30.72	946.1	91 33 36.30	953.8	271 59 23	92 00 16	Fairview	2,703.9
					310 19 34	130 20 32	Leonard	3,873.5
Walton's gin chimney	31 20 23.07	710.5	91 32 13.48	356.3	277 33 16	97 33 45	Corena	1,464.1
					20 30 4	200 30	Rosland	576
Roseland gin chimney	31 19 27.26	839.5	91 31 50.03	1,322.6	145 8 46	325 8 30	Roseland	1,437.5
					208 34 47	28 35 3	Corena	1,738.6
Ober's gin chimney	31 18 28.02	862.9	91 32 26.78	708	235 3 41	55 4 27	Ferguson	2,825.1
					259 34 1	79 34 49	Strother's	2,473.8
Home Place store gable	31 16 22.29	686.4	91 33 48.08	1,271.7	305 43 45	125 44 14	Cerro Gordo	1,848.4
					357 9 27	177 9 27	Home Place	80.8
Fairview Landing, river front of new store	31 19 49.76	1,532.4	91 31 51.22	1,353.9	226 00 6	46 00 23	Corena	1,190.9
					324 5 16	144 5 45	Strother's	2,553.6
House at Woodyard chimney	31 16 21.25	654.4	91 34 30.00	795.9	345 50 8	165 50 14	Allaway	1,206.9
					70 29 24	250 28 53	Jackson	1,728
Bayou Sara gin chimney	30 45 59.68	1,837.8	91 23 23.57	626.8	300 54 58	120 55 20	Alexander Creek	1,884.5
					26 28	180 26 28	Northwest base	1,572
Saint Francisville Catholic church cross	30 46 26.82	825.8	91 23 25.55	679.4	335 54 24	155 54 50	Southeast base	3,293.2
					359 2 17	179 02 18	Northwest base	2,406.2
Saint Francisville Episcopal church	30 46 32.40	997.7	91 23 14.55	386.8	341 41 18	161 41 38	Southeast base	3,347.3
					5 33 8	185 35 3	Northwest base	2,591.7
Doyle's chimney	30 45 21.07	648.9	91 22 12.68	337.2	31 10 54	211 10 42	Southeast base	1,147
					110 8 42	299 8 8	Depot	2,002.7
Colored church belfry	30 44 30.99	954.3	91 22 13.59	361.5	134 33 39	314 33 28	Southeast base	799.4
					172 6 23	352 6 18	Alexander Creek	1,779.6
Bayou Sara, vane	30 45 58.17	1,791.3	91 23 35.43	942.2	295 29 54	115 30 31	do	2,140.6
					348 45 19	168 45 24	Northwest base	1,555.1
Bayou Sara school-house	30 46 4.52	139.2	91 23 38.22	1,016.3	299 6 44	119 7 23	Alexander Creek	2,296.3
					16 26 42	196 26 32	Bovard	1,866
Bayou Sara Methodist church	30 46 8.34	256.7	91 23 40.59	1,079.4	300 49 27	120 50 7	Alexander Creek	2,409.6
					346 31 43	166 31 51	Northwest base	1,890.5
Bovard House	30 45 1.58	48.7	91 23 42.73	1,136.5	109 59 36	289 59 28	Bovard	434.5
					246 23 56	66 24 0	Northwest base	542.6
Bovard sugar-house chimney	30 44 52.52	1,617.4	91 13 52.06	1,384.6	109 40 22	289 39 36	Willow Bar	2,521.7
					165 6 22	345 6 12	Magee	1,832
Saint Francis church	30 44 52.08	1,603.9	91 24 56.27	1,496.6	142 16 57	322 16 44	Willow Bar	1,090.2
					214 43 37	34 44 1	Magee	2,170.9
Claiborne sugar-house chimney	30 43 47.36	1,458.3	91 27 36.87	980	112 15 21	292 14 45	Woodyard	2,021.5
					204 27 3	24 27 15	Bockel	1,540
Pederre overseer's house	30 43 43.58	1,342.1	91 28 53.75	1,429.9	191 10 2	11 10 5	Woodyard	898.5
					262 2 34	82 2 40	Saint Maurice	289.6

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Morrison's sugar-house chimney	30 43 28.40	874.5	91 31 37.67	1,002.3	169 43 54	349 43 50	McCallum's Point	1,303.4
					178 26 56	358 26 55	Fischer	2,122.1
Stewart sugar-house chimney	30 43 43.50	1,339.6	91 31 55.75	1,483.2	194 20 33	14 20 41	Fischer	1,710.2
					196 54 57	16 55 2	McCallum's Point	855
New Texas chimney	30 46 10.77	321.6	91 35 38.08	1,012.6	206 8 43	26 8 56	New Texas	1,483.5
					350 35 6	170 35 12	Vignes	1,895
New Texas gin chimney	30 46 13	400.3	91 35 34.22	910	203 34 1	23 34 12	New Texas	1,878.4
					353 53 40	173 53 44	Vignes	1,948.9
New Texas flag-staff	30 46 28.15	866.8	91 35 28.61	760.9	262 30 30	82 30 54	Neal	1,250.3
					358 37 3	178 37 4	Vignes	2,405.3
Quitman statue	30 46 26.20	806.8	91 35 25.66	682.4	200 40 35	20 40 41	New Texas	915.7
					340 30 44	160 30 59	Leonard	2,408.1
Fischer's Landing	30 47 18.95	583.5	91 34 54.17	1,440.1	12 12 5	192 11 48	Vignes	4,060.6
					33 48 30	213 48 20	New Texas	973.9
Bougeoir gin	30 46 42.34	1,303.8	91 35 31.13	827.7	232 29 39	52 29 48	New Texas	500.9
					281 50 23	101 50 48	Neal	1,234.9
Ober gin	30 46 28.13	866.2	91 35 35.80	952	263 28 39	83 29 7	Neal	1,440.3
					335 15 48	155 16 9	Leonard	2,564.9
New House	30 47 21.04	648	91 31 47.90	1,273.5	110 44 22	290 43 56	Shaw	1,438.0
					163 7 32	343 7 25	Raccourci Point	1,193.4
Barrow's chimney	30 47 39.47	1,215.5	91 31 31.60	840.3	88 7 59	268 7 25	Shaw	1,779.8
					126 23	306 22 45	Raccourci Point	968.4
Wade shed	30 52 27.49	846.6	91 31 7.38	196	10 51 27	190 51 4	Cotton	6,264.6
					156 34 6	336 34 3	Wade	412.6
Deserted cabin	30 52 40.63	1,251.2	91 31 14.78	392.5	60 29 37	249 29 23	Stevenson	754.7
					142 13 26	322 12 50	Stump	3,056.5
Tunica Landing	30 55 15.19	467.8	91 33 1.72	45.7	4 18 1	184 17 59	Letherman	1,220.2
					105 23 37	285 23 5	Rowe	1,728
Coal-yard house	30 55 00.87	26.8	91 34 1.68	44.6	111 33 27	291 33 23	Saint Bernard	214.5
					175 10 15	355 16 14	Rowe	903
Old River House	30 54 48.63	1,497.5	91 36 36.54	970.2	146 28 33	326 28 16	Cut-off	1,018.2
					217 00 10	37 00 33	Cheatham	1,185.3
Proctor chimney	30 54 47.88	1,474.4	91 30 7.07	187.7	120 18 27	300 17 53	Cut-off	2,106.5
					175 55 38	355 55 37	Cheatham	972.2
Smithland gin	30 55 44.87	1,381.8	91 39 6.17	103.8	181 58 22	1 58 24	Angola	3,274.4
					240 36 24	60 36 51	Acklen	1,601.2

					179 27 10	[illegible]	Angola	[illegible]
Hog Point Landing	30 55 50.73	1,562.4	91 39 00.81	21.5	251 3 46	71 4 11	Acklen	1,403.1
Miles chimney	30 55 16.66	513.1	91 38 21.88	581	151 17 30	331 16 56	Kingsbury	4,606.9
					191 2 24	11 2 30	Acklen	1,532.9
Smith chimney	30 55 52.05	1,603	91 39 3.62	96	180 50 35	50 36	Angola	3,051.7
					253 30 59	73 31 26	Acklen	1,462
Red River warehouse	30 58 00.20	6.2	91 39 50.16	1,331.2	245 15 28	65 16 5	Eastman	2,110.2
					304 56 58	124 57 23	Angola	1,561.6
Red River light	30 58 35.32	1,087.7	91 39 26.16	694.2	278 49 55	98 50 20	Eastman	1,294.9
					341 58 38	161 58 50	Angola	2,078.5
Kingsbury store	30 57 24.57	756.8	91 39 46	1,220.8	191 9 10	11 9 10	Kingsbury	103.6
					260 10 58	80 11 21	Angola	1,187.1
Red River school	30 58 11.06	340.5	91 39 58.86	1,562.1	255 40 23	75 41 5	Eastman	2,216.1
					309 8 5	129 8 34	Angola	1,947.9
Tregar's chimney	30 59 27.59	849.7	91 38 40.74	1,080.8	357 38 54	177 38 55	Eastman	1,810.2
					24 54 29	204 53 56	Kingsbury	4,065
Black Hawk gin	31 9 32.43	998.7	91 37 50.68	1,342.2	211 24 23	31 24 32	Bullen	885.9
					301 44 50	121 44 59	Black Hawk	518.4
Tower	31 13 4.87	150	91 37 35.91	950.5	220 53 22	40 53 37	Union Point	1,155.7
					314 27 19	134 28 14	Peach Grove	3,936.2
Union Point gin	31 12 51.92	1,599	91 37 43.16	1,142.3	216 41 58	36 42 17	Union Point	1,566.9
					240 00 7	60 00 48	Kienstra	2,421.0
Bougère gin	31 16 48.41	1,490.7	91 30 53.20	1,407.2	28 12 50	208 12 13	Pecan	3,962.2
					36 18 22	216 18 19	Bougère	217.9
Bougère chimney	31 16 41.87	1,381.8	91 30 53.90	1,428.1	324 51 21	144 51 36	Point	1,310
					28 42 30	208 41 54	Pecan	3,876.1
Base, east end (Vidalia)	31 33 42.59	1,311	91 25 18	474.6				
Base, west end (Vidalia)	31 35 1.02	31.4	91 26 24.01	633	324 13 2.4	144 13 37	East base	2,977.272
Giles	31 36 4.48	138	91 23 4	1,159.8	29 34 1.8	209 33 12.6	East base	5,023.8
					65 9 8.5	245 7 44.7	West base	4,649.2
Lookout	31 33 12.15	374.2	91 25 10.76	283.7	203 18 43.2	23 19 28.6	Giles	5,779.4
					168 29 25.6	348 29 21.8	East base	956.7
Natchez Catholic Church-spire cross	31 33 28.70	883.9	91 24 6.75	178	73 12 25.6	253 11 52.1	Lookout	1,763.4
					187 7 32.4	7 7 44.3	Giles	4,835.1
Palo Alto (or Palo Alto 2)	31 34 46.02	1,417.2	91 25 9.80	258.3	103 17 22.1	283 16 43.2	West base	2,010.4
					6 18 56.5	186 18 52.2	East base	1,965.4
Gaither (or Gaither 2)	31 33 1.10	33.9	91 26 47.59	1,255.1	262 24 2	82 24 53	Lookout	2,576.4
					241 35 18	61 36 6	East base	2,686.2
Government Light, Natchez Island	31 30 14.07	433.4	91 30 30.86	814.3	287 1 12	107 1 39	Lemley	1,441.5
					351 1 57	171 2 7	Ivanhoe	3,206.9
Tall Pine	31 26 7.65	235.6	91 26 5.19	137	22 51 37	202 51 9	Ellis Cliff	3,602.5
					64 15 45	244 14 20	Esperance	4,770.3
Government Light, Hutchins' Landing	31 24 22.32	687.4	91 27 9.76	257.8	53 41 7	233 40 15	Bourbon	3,287.9
					133 6 18	313 5 27	Page	3,540.2

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Leonard's gin stack	31 23 .89	56.1	91 31 18.44	487.3	108 28 41	288 28 27	Leonard	727.1
					207 1 28	27 1 53	Pecan	2,763
Corena gin stack	31 19 58.96	1,815.8	91 31 00.40	10.6	27 20 45	207 20 23	Obers	2,407.2
					138 52 4	318 51 54	Corena	730.4
Government Light, Deadman's Bend	31 16 14.82	456.5	91 31 42.30	1,118.9	65 4 26	245 3 50	Cerro Gordo	2,014.8
					168 53 28	348 53 23	Fritz	1,371.5
Cerro Gordo gin stack	31 15 39.03	1,202.6	91 32 54.34	1,437.5	131 26 5	311 25 37	Home Place	1,890.8
					197 21 32	17 21 34	Cerro Gordo	264.4
Bluff gin	31 1 46.63	1,436	91 32 50.19	1,381.1	62 27 56	242 26 18	Tarbert	5,677.5
					131 49 55	311 49 39	Rock Hill	1,072.5
Langside chimney	31 1 58.56	1,803.4	91 34 44.22	1,172.7	179 27 58	359 27 58	Lum	1,671.8
					261 6 16	81 6 59	Rock Hill	2,252
Langside gin	31 1 46.27	1,425	91 34 40.20	1,068.5	58 27 13	238 25 44	Tregar	5,354.1
					62 37 15	242 36 9	Ker's Point	3,811.4
Tarbert's stable	31 00 57.96	1,784.9	91 35 29.52	783	82 42 35	262 41 53	Ker's Point	2,095.6
					237 7 16	57 8 23	Rock Hill	4,079.6
Riverside chimney	31 3 18.97	584.2	91 30 46.10	1,223.4	62 19 23	242 15 54	Tregar	12,168.6
					82 46 28	262 44 25	Lum	6,360.7
Tarbert House	31 1 14.69	452.4	91 35 20.65	547.7	71 20 57	251 20 12	Ker's Point	2,442.1
					197 27 8	17 27 27	Lum	3,168.8
Clarksville chimney	31 3 46.04	1,417.8	91 33 12.48	330.8	56 18 4	236 12 16	Lum	2,945.6
					136 5 25	316 5 8	Point Breeze	1,272.9
Loch Leven Landing	31 10 7.72	237.7	91 36 49.78	1,318.2	73 58 26	253 58 4	Pullen	1,197.8
					205 37 35	25 37 37	Lock Leven	255.5
Loch Leven gin	31 10 27.06	833.3	91 36 29.83	790	41 1 9	221 00 36	Black Hawk	2,591.3
					61 7 40	241 7 7	Pullen	1,918.2
Kienstra upper store	31 13 33.71	1,038.1	91 36 23.59	624.3	346 12 32	166 12 40	Peach Grove	3,753.5
					89 17 2	269 16 39	Union Point	1,157.8
Kienstra lower store	31 13 17.58	541.4	91 36 14.82	392.3	100 8 3	289 7 36	Union Point	1,470.9
					150 12 7	330 12 2	Kienstra	484.3
Kienstra chimney	31 13 39.34	1,211.4	91 36 23.84	631	30 17	180 30 17	Kienstra	249.8
					80 43 35	260 43 13	Union Point	1,166.8
Jackson gin	31 16 04.98	153.4	91 36 12.53	331.1	113 00 57	293 00 50	Point	860.2
					133 56 42	313 56 18	Bougère	1,674.3
Jackson's chimney	31 15 58.65	1,806.2	91 36 17.50	465.3	141 42 13	321 41 52	Bougère	1,728.7
					140 32 56	320 32 52	Point	380.8
Natchez Astronomical Station, transit of 1878	31 33 27.16	836.5	91 24 5.20	137.1				

Wade House	[illegible]	[illegible]	[illegible]	[illegible]	137 33 37	317 33 3	Stump	2,585.0
Dunham's Bar	31 36 6.13	188.8	91 20 26.96	710.6	270 39 58.5	90 41 23.9	Giles	4,296
					357 46 52.8	177 46 53.8	West Base	2,006.8
Ralston	31 35 24.70	760.7	91 27 6.86	180.9	210 30 03.4	30 30 26.3	Dunham's	1,653.7
					302 50 38.8	122 51 1.2	West Base	1,844.8
Waterloo, 2	31 36 19.80	609.8	91 28 41.39	1,090.8	276 45 53	96 47 8.4	Dunham's Bar	3,508.5
					301 14 48.7	124 15 38.2	Ralston	3,014.8
Bullock	31 37 33.69	1,037.6	91 28 57.89	1,525.8	304 7 11.1	124 8 30.3	Dunham's Bar	4,606.1
					349 10 33.7	169 10 42.5	Waterloo, 2	2,816.9
Goodhope	31 38 17.82	548.8	91 27 20.68	544.9	30 20 33.6	210 19 51.3	do	4,211.5
					62 3 35.7	242 2 44.7	Bullock	2,900.1
Faucett	31 37 40.79	1,256.1	91 27 9.59	252.7	85 37 34.8	265 36 38	do.	2,862.5
					165 38 3.1	345 37 57.3	Goodhope	1,177.3
Connor	31 37 51.44	1,584.1	91 25 35.93	946.7	82 26 24.3	262 25 35.2	Faucett	2,490
					106 24 38	286 23 43.1	Goodhope	2,877.4
Brenham	31 37 14.83	456.7	91 25 19.38	510.7	105 23 49	285 22 51.2	Faucett	3,012.7
					158 50 58.1	338 50 49.4	Connor	1,208.8
Rifle Point	31 37 58.53	1,802.5	91 24 58.77	1,548.5	21 59 00.3	201 58 49.5	Brenham	1,451.4
					77 25 38.8	257 25 19.3	Connor	1,003.5
Elysian Fields	31 37 21.58	664.6	91 24 22.72	598.7	82 5 2.6	262 4 32.9	Brenham	1,507.6
					140 9 10.5	320 8 51.6	Rifle Point	1,482.4
Vancluse	31 38 43.86	1,350.7	91 23 55.90	1,472.8	15 35 10.1	195 34 56.	Elysian Fields	2,631.1
					49 52 45.2	229 52 12.2	Rifle Point	2,166.5
Bluff	31 38 43.85	1,350.4	91 23 11.93	314.3	36 21 48.7	216 21 11.5	Elysian Fields	3,140.7
					90 00 56.6	270 00 33.5	Vancluse	1,158.5
Davis	31 39 46.75	1,439.8	91 23 37.62	990.9	340 44 18.3	160 44 31.8	Bluff	2,052.1
					13 57 37.7	193 57 28.1	Vancluse	1,995.9
Quitman	31 40 37.87	1,166.3	91 22 56.52	1,488.6	6 35 39.6	186 35 31.5	Bluff	3,535.2
					34 30 50.4	214 30 28.8	Davis	1,910.9
Shamrock	31 40 30.20	930.1	91 23 44.48	1,171.4	259 24 33.4	79 24 58.6	Quitman	1,285.1
					352 18 37.9	172 18 41.5	Davis	1,350.6
Fairchild	31 41 39.86	1,227.6	91 23 14.21	874.2	346 17 5.7	166 17 15	Quitman	1,965.3
					20 23 11.6	200 22 55.7	Shamrock	2,288.8
Canebrake	31 42 00.20	6.2	91 24 9.96	262.1	293 6 31.9	113 7 1.2	Fairchild	1,596
					346 23 34.2	166 23 47.6	Shamrock	2,852
Duck Bar	31 43 2.42	74.6	91 23 24.65	649	353 49 49.9	173 49 55.4	Fairchild	2,557.6
					31 54 21.3	211 53 57.5	Canebrake	2,257.3
Hole in Wall	31 43 13.71	422.4	91 24 9.46	249.1	286 25 37.3	106 26 00.8	Duck Bar	1,229.9
					19 50.2	180 19 49.9	Canebrake	2,264.2
Wilson	31 43 34.96	1,076.4	91 22 58.45	1,538.5	34 32 57.3	214 32 43.5	Duck Bar	1,216.4
					70 43 24.1	250 42 46.8	Hole in Wall	1,980.5
L'Argent	31 44 28.46	876.5	91 23 42.49	1,118.2	324 52 41.8	144 53 4.5	Wilson	2,015
					17 8 34.5	197 8 20.3	Hole in Wall	2,409.3

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Burnett	31 44 54.48	1,677.8	91 21 30.97	815	43 14 21.9	223 13 35.9	Wilson	3,362
					76 58 38.8	256 57 29.6	L'Argent	3,558.3
Cole's Island	31 46 18.22	561.2	91 21 59.24	1,558.6	343 54 31.4	163 54 46.3	Burnett	2,684.2
					17 13 30.4	197 12 59.2	Wilson	5,264.6
Race Course	31 45 59.34	1,827.5	91 22 44.55	1,172.4	244 00 12.2	64 00 36.	Cole's Island	1,326.5
					315 53 19.7	135 53 58.4	Burnett	2,782.2
Service	31 47 6.89	212.3	91 21 59.94	1,576.8	359 17 49.2	179 17 49.6	Cole's Island	1,499.4
					29 26 1.6	209 25 38.1	Race Course	2,388.9
Waterproof	31 48 5.39	166	91 22 56.59	1,488.5	320 24 7.5	140 24 37.3	Service	2,338.2
					355 20 8.5	175 20 14.8	Race Course	3,895.8
Ashland	31 48 25.37	781.5	91 20 49.40	1,299.3	37 31 9.5	217 30 32.3	Service	3,047.5
					79 35 8.7	259 34 1.7	Waterproof	3,401.9
Golman	31 48 55.29	1,702.9	91 21 18.77	493.6	320 1 28.6	140 1 44.1	Ashland	1,202.8
					59 9 29.5	239 8 37.9	Waterproof	2,997.2
Buena Vista	31 49 4.48	138	91 19 38.29	1,007	57 13 30.2	237 12 52.7	Ashland	2,224.6
					83 53 37.2	263 52 44.2	Golman	2,657.8
Kemp's Landing	31 49 47.47	1,462	91 19 44.54	1,171.1	352 55 28.6	172 55 31.9	Buena Vista	1,334.3
					57 2 30.2	237 1 40.5	Golman	2,953.7
Spithead	31 49 23.56	725.6	91 18 1.30	34.3	77 2 8.2	257 1 17.1	Buena Vista	2,617.1
					105 11 14	285 10 19.6	Kemp's Landing	2,813
Harper's Island	31 50 31.62	973.9	91 16 1.82	47.8	56 17 46	236 16 48	Spithead	3,777.1
					76 56 39.7	256 54 42.3	Kemp's Landing	6,012.2
Pecon Grove	31 49 54.98	1,693.3	91 15 47.50	1,248.8	74 37 45.5	254 36 34.0	Spithead	3,649.5
					161 32 39.1	341 32 31.5	Harper's	1,189.6
CXI Bar	31 50 28.38	874.1	91 14 19.93	523.9	65 55 54.8	245 55 8.0	Pecan Grove	2,522
					93 8 17.2	272 7 23.4	Harper's Island	2,681
Forman	31 50 8.46	260.6	91 13 48.62	1,278.3	82 26 39.1	262 25 30.4	Pecan Grove	3,153.4
					126 42 14.2	306 41 57.7	CXI Bar	1,026.8
Lee's Point	31 51 6.88	211.9	91 13 15.05	395.7	26 8 .2	206 7 42.5	Forman	2,004.1
					55 12 13.2	235 11 39	CXI Bar	2,077.4
Rodney	31 51 14.86	457.7	91 12 26.35	692.8	46 36 45.3	226 36 1.9	Forman	2,970.7
					79 8 16.5	259 7 52.8	Lee's Point	1,808.6
Clark	31 52 35.12	1,081.7	91 13 34.40	906.4	324 4 13.8	144 4 40.8	Rodney	3,052.8
					349 20 56.6	169 21 6.9	Lee's Point	2,765.5
Lewis	31 52 24.36	750.3	91 14 22.01	578.5	255 8 .1	75 8 35.2	Clark	1,292.2
					305 8 27.4	125 0 28.5	Rodney	3,718.3

Sandy Point	31 53 44.86	1,381.6	91 13 43.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					22 22 .7	202 21 40.2	Lewis	2,081.2
Saint Joseph	31 54 4.73	145.7	91 14 20.91	540.4	301 41 4	121 41 28.0	Sandy Point	1,104.7
					0 32 9.9	180 32 9.3	Lewis	3,091.5
Gold Bottom	31 54 34.07	1,049.4	91 12 34.26	900.0	50 4 54	230 4 17.6	Sandy Point	2,361.7
					72 7 50	252 6 53.6	Saint Joseph	2,944.4
Gillespie	31 55 14.20	437.2	91 12 53	1,392.2	338 16 47.9	158 16 57.8	Gold Bottom	1,380.5
					47 11 29.8	227 10 43.3	Saint Joseph	3,148.6
Watson	31 55 42.60	1,312.0	91 11 58.96	1,548.6	23 43 12.1	203 42 53.4	Gold Bottom	2,305.6
					58 21 39.2	238 21 10.6	Gillespie	1,067.5
Bruinsburg	31 55 54.05	1,664.6	91 10 24.75	650.1	54 6 16.2	234 5 7.7	Gold Bottom	4,200.6
					81 53 56	261 53 6.2	Watson	2,499.8
Bondurant	31 56 33.20	1,022.5	91 11 3.84	100.9	310 35 15.4	130 35 36.1	Bruinsburg	1,583.7
					42 54 .3	222 53 31.1	Watson	2,127.4
Waveland	31 58 2.29	70.5	91 9 43.67	1,140.6	15 16 54.1	195 16 32.4	Bruinsburg	4,094.6
					37 30 13.5	217 29 31.1	Bondurant	3,458.6
Bayou Pierre	31 57 54.70	1,684.6	91 8 56.12	1,473.4	32 4 16.5	212 3 29.6	Bruinsburg	4,385
					100 36 43.9	280 36 18.7	Waveland	1,270.4
Hard Scrabble	31 58 50.95	1,569.1	91 9 2.30	60.5	354 38 48.2	174 38 51.5	Bayou Pierre	1,740.4
					35 55 55.3	215 55 33.4	Waveland	1,851.1
Saunders	31 58 40.26	1,239.8	91 8 23.30	611.6	31 33 22.1	211 33 4.7	Bayou Pierre	1,646.9
					107 50 2.6	287 49 41.9	Hard Scrabble	1,075.7
Knight	32 00 23.85	734.6	91 7 52.03	1,365.3	14 25 46	194 25 29.4	Saunders	3,294.7
					32 48 54.7	212 48 17.5	Hard Scrabble	3,404.6
Whitehall Chute	31 59 56.94	1,753.6	91 7 22.34	586.3	34 7 27.7	214 6 55.4	Saunders	2,852.9
					136 46 23.6	316 46 7.9	Knight	1,137.7
Disharoon	32 1 00.44	13.6	91 6 16.25	426.5	41 34 12.1	221 33 37.1	Whitehall Chute	2,614.4
					65 51 22.5	245 50 31.8	Knight	2,754.8
Hughes	32 00 30.27	932.3	91 5 57.88	1,519	65 9 10.6	245 8 25.8	Whitehall Chute	2,443.1
					152 34 50	332 34 40.3	Disharoon	1,046.9
Grand Gulf Island	32 1 34.56	1,064.4	91 4 59.75	1,567.8	37 37 3.6	217 36 32.8	Hughes	2,499.7
					62 22 37.3	242 21 56.8	Disharoon	2,266
Crandall	32 1 44.04	1,356.4	91 5 35	918.3	287 30 52.8	107 31 11.5	Grand Gulf Island	970.1
					38 52 32.9	218 52 11	Disharoon	1,724.8
Thrasher	32 2 34.17	1,052.4	91 5 18.64	488.9	344 53 31	164 53 41	Grand Gulf Island	1,901.8
					15 32 24.9	195 32 16.2	Crandall	1,602.7
Hard Times	32 2 38.27	1,178.7	91 7 14.25	373.8	272 22 39.3	92 23 40.6	Thrasher	3,036
					302 40 16.7	122 41 9.3	Crandall	3,094
Yucatan Bar	32 3 3.85	118.6	91 6 33	865.7	328 14 12.9	148 14 43.7	Crandall	2,891.4
					53 56 36.1	233 56 14.2	Hard Times	1,338.6
Wilson	32 3 46.77	1,440.4	91 7 35.78	938.4	308 45 7.2	128 45 40.5	Yucatan Bar	2,111.7
					345 00 52.6	165 1 4	Hard Times	2,184.2
Sycamore	32 4 39.46	1,215.8	91 6 26.06	683.3	3 32 15.7	183 32 12	Yucatan Bar	2,950.5
					48 24 54.1	228 24 17.1	Wilson	2,444.8

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Buck Ridge	32 5 34.79	1,071.5	91 6 45.06	1,181.5	343 42 7.5	163 42 17.6	Sycamore	1,775.7
					21 47 35.3	201 47 8.4	Wilson	3,583.2
Swamp	32 4 39.54	1,217.7	91 4 48.38	1,268.7	89 57 1.9	269 56 10	Sycamore	2,561.7
					119 5 27.2	299 4 25.2	Buck Ridge	3,501.1
Munce	32 6 7.52	231.6	91 3 44.83	1,175.4	31 35 45.6	211 35 11.9	Swamp	3,181.4
					57 19 45.2	237 18 19.6	Sycamore	5,023.8
Elder	32 5 10.25	315.7	91 3 21.17	555	67 32 10.2	247 31 23.9	Swamp	2,475.1
					160 37 37.4	340 37 24.8	Munce	1,869.9
Big Black	32 6 35.45	1,091.9	91 2 34.07	893.1	25 12 19.4	205 11 54.4	Elder	2,900.4
					65 7 31.3	245 6 53.7	Munce	2,044.9
Gander	32 7 34.12	1,050.9	91 3 36.38	953.5	317 52 58.1	137 53 31.2	Big Black	2,435.9
					4 44 43.3	184 44 38.8	Munce	2,676.5
Point Pleasant	32 7 53.77	1,656	91 4 42.77	1,120.8	289 10 13	109 10 48.3	Gander	1,842.4
					335 5 45.1	155 6 15.9	Munce	3,607.9
Old River	32 9 6.86	211.3	91 2 16.60	434.0	36 12 38.5	216 11 56.1	Gander	3,540.1
					59 34 7.6	239 32 49.8	Point Pleasant	4,443.5
Cannon	32 8 15.19	467.9	91 2 33.23	870.8	79 00 47.8	258 59 38.9	Point Pleasant	3,458.8
					195 18 51.9	15 19 00.8	Old River	1,650.2
Morgan	32 8 52.55	1,618.4	91 00 54.77	1,435	65 58 16.2	245 57 23.8	Cannon	2,325.4
					101 37 22.9	281 36 39.4	Old River	2,189.1
Wilkinson	32 10 21.81	671.7	91 1 20.27	530.9	346 20 19.3	166 20 32.9	Morgan	2,829.3
					32 35 47.4	212 35 17 4	Old River	2,739.9
Williams	32 10 28.87	889.2	91 00 30.25	792.4	13 13 24.9	193 13 11.9	Morgan	3,035.5
					80 35 9.2	260 34 42.6	Wilkinson	1,328.5
Kellogg	32 11 6.11	188.2	91 1 44.75	1,172.1	300 26 18.7	120 26 58.4	Williams	2,263.8
					334 49 38 1	154 49 51 1	Wilkinson	1,507.6
Guy	32 11 43.57	1,341.9	91 1 31.81	833	324 58 11.1	144 58 43.9	Williams	2,809.8
					16 22 1.1	196 21 54.2	Kellogg	1,202.0
Coons	32 11 38.08	1,172.9	91 2 12.91	338.2	261 4 32	81 4 58.9	Guy	1,089.7
					323 0 48.5	143 10 3.5	Kellogg	1,230.5
Hankinson	32 12 14.84	457.1	91 1 42.17	1,104.3	1 49 51.3	181 49 40.9	Kellogg	2,118.3
					35 25 24.9	215 25 8.5	Coons	1,380.5
Moore	32 12 31.37	966.2	91 3 07.41	104.1	282 50 28.9	102 51 14.3	Hankinson	2,280.0
					318 59 11.5	138 59 40.5	Coons	2,175.3
Walton, 2	32 13 14.99	461 7	91 1 09.70	253.9	24 39 10	204 38 52.7	Hankinson	2,038.7
					66 27 22.7	246 26 20.0	Moore	3,869.7

					[illegible]	[illegible]	Moore	3,5[illegible]
Gantt	32 13 2.84	72.1	91 00 28.53	747.1	109 53 1.4	280 52 39 4	Walton, 2	1,146.4
					131 38 12.8	311 57 41.9	Diamond Island	2,007.1
Cut-off	32 13 38.48	1,185.2	90 50 9.43	246.9	61 45 8.4	241 44 26.2	Gantt	2,351.5
					93 41 11.9	273 39 59.3	Diamond Island	3,570.8
Simrall	32 13 00.14	4.8	90 58 36.07	94.4	91 19 41.1	271 18 41.1	Gantt	2,945.8
					143 30 47.8	323 30 30	Cut-off	1,468.9
Charley	32 13 42.30	1,302.7	90 58 28.56	747.7	8 36 43.6	188 36 39.6	Simrall	1,313.4
					83 43 46.4	263 43 24.6	Cut-off	1,076.6
Myer	32 13 44.93	1,383.7	90 57 10.77	281.9	58 18 17	238 17 31.5	Simrall	2,625.4
					87 43 41.1	267 43 00.6	Charley	2,038.5
South Bedford	32 14 39.35	1,211.9	90 57 38.20	999.8	336 48 23.1	156 48 37.7	Myer	1,823.7
					26 22 41.4	206 22 10.5	Simrall	3,411
Warrenton	32 14 54.78	1,687.1	90 56 35.30	924	23 21 1.9	303 20 43	Myer	2,343.4
					73 54 28.7	253 53 55.2	South Bedford	1,713.9
North Bedford	32 15 23.65	728.4	90 57 9.72	254.4	314 37 31	134 37 49.4	Warrenton	1,266
					28 39 26.6	208 39 11.4	South Bedford	1,555
Big Bayou	32 16 2.11	65	90 56 34.22	895.5	00 46 49.6	180 46 49	Warrenton	2,074.3
					38 6 29.2	218 6 10.3	North Bedford	1,505.6
Reade	32 16 48.24	1,485.7	90 57 41.30	1,080.5	308 59 6.3	128 59 42.1	Big Bayou	2,258.5
					342 24 1.6	162 24 18.5	North Bedford	2,733.6
Last	32 15 53.70	1,653.9	90 57 47.92	1,253.9	185 53 28.9	5 53 32.4	Reade	1,688.9
					262 20 45.5	82 21 24.8	Big Bayou	1,946.2
Biggs	32 17 54.94	1,692.1	90 57 27.43	717.6	338 9 45	158 10 13.4	Big Bayou	3,743.9
					8 10 19.9	188 10 9	Last	3,772.2
Kemp	32 17 25.10	773.1	90 56 1.84	48.1	44 36 20.5	224 35 23.9	Last	3,953.8
					112 19 8.4	292 18 22.7	Biggs	2,420.7
Base, southwest end (delta)	32 19 4.60	141.7	90 56 13.19	345	354 27 51.6	174 27 57.7	Kemp	3,079.3
					42 9 7.7	222 8 28.1	Biggs	2,894.3
Walnut	32 18 .22	6.8	90 54 32.91	860	65 4 20.5	245 3 33	Kemp	2,566
					127 5 41.8	307 4 48.2	Southwest Base	3,288.7
Base, northeast end (delta)	32 20 1.61	49.8	90 54 53.95	1,410.7	351 37 33.9	171 37 45.1	Walnut	3,779.6
					49 43 51.6	229 43 9.2	Southwest Base	2,716.6
Fort	32 20 26.16	805.8	90 53 5.04	131.9	75 8 24	255 7 25.8	Northeast Base	2,946.7
					27 5 4	207 4 17	Walnut	5,048.9
Island	32 21 7.11	219.2	90 53 41.73	1,091	322 44 38.4	142 44 58	Fort	1,584.8
					43 6 45.9	223 6 7.3	Northeast Base	2,763.5
Harris	32 20 .09	2.7	90 56 52.59	1,375.3	315 17 23.3	135 18 38	Walnut	5,194.6
					269 7 25.4	89 8 28.9	Northeast Base	3,103.3
King	32 20 35.58	1,095.7	90 56 37.18	972.2	272 58 35.8	93 0 29.3	Fort	5,556.1
					325 48 14.6	145 49 21.1	Walnut	5,785
New King	32 20 38.82	1,195.7	90 56 46.03	1,203.7	8 11 9.4	188 11 5.9	Harris	1,205.2
					291 20 38.1	111 21 38.1	Northeast Base	3,147.2

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Crane	32 20 36.30	1,118	90 57 57.10	1,492.9	267 36 7.6	87 36 45.6	New King	1,859.9
					303 27 56.4	123 28 30.9	Harris	2,022.2
Hutchinson	32 21 9.42	290.2	90 57 40.78	1,066.4	22 41 17	202 41 8.3	Crane	1,106.9
					303 21 32.6	123 22 1.9	New King	1,714.2
Williams	32 19 52.64	1,621.3	90 58 9.23	241.3	193 16 15.2	13 16 21.7	Crane	1,381.7
					263 27 37	83 28 18	Harris	2,017.3
Mattingly	32 20 44.06	1,357.2	90 50 5.67	148.2	250 36 24.5	70 37 9.9	Hutchinson	2,353
					317 0 59.5	137 1 29.7	Williams	2,165.2
Yazoo	32 22 7.31	225.1	90 59 10.54	275.6	357 9 20.6	177 9 23.2	Mattingly	2,567.3
					307 13 15.7	127 14 3.7	Hutchinson	2,947.2
Nichols	32 21 48.94	1,507.4	91 00 9.37	245.1	249 48 .5	69 48 32	Yazoo	1,038.8
					320 10 59.5	240 11 33.6	Mattingly	2,601.5
Utz	32 23 3.09	95.1	91 00 58.41	1,526.7	330 41 38.5	150 42 4.8	Nichols	2,619.1
					301 20 54.9	121 21 52.7	Yazoo	3,302
Pugh	32 25 5.92	182.3	91 00 22.92	598.8	13 46 36.7	193 46 17.7	Utz	3,895.4
					341 1 12.1	161 1 50.9	Yazoo	5,817.8
Levee	32 25 25.23	777.2	91 1 15.48	404.4	293 25 17.5	113 25 45.7	Pugh	1,496.5
					354 10 58	174 11 7.1	Utz	4,401
Mayor	32 25 24.56	756.4	91 2 11.02	287.9	281 29 5.8	101 30 3.7	Pugh	2,882.2
					336 27 51.7	156 28 30.6	Utz	4,752.9
McBurney	32 27 42.24	1,301.3	91 2 11.12	290.6	359 57 48.8	179 57 48.9	Mayer	4,241.1
					329 34 46.9	149 35 44.9	Pugh	5,583.6
Byrne	32 27 9.22	284	91 4 25.47	665	253 49 17.2	73 50 29.3	McBurney	3,653.1
					312 32 21.7	132 33 33.8	Mayer	4,767.4
Lake	32 25 58.43	1,799.7	91 2 1.88	49.1	120 11 4.6	300 9 47.6	Byrne	4,338.5
					12 53 43.4	192 53 38.5	Mayer	1,070.1
Purvis	32 27 57.47	1,770.2	91 3 22.04	575.7	48 6 9.2	228 5 36.2	Byrne	2,225.4
					284 12 16.6	104 12 54.7	McBurney	1,910.6
Sand Island	32 28 39.08	1,203.8	91 4 59.09	1,542.6	296 49 18.6	116 50 10.7	Purvis	2,840.8
					342 23 52.2	162 24 10.3	Byrne	2,903.9
Morancy	32 27 56.91	1,752.9	91 6 8.45	220.7	234 20 45.7	54 21 22.9	Sand Island	2,228.9
					298 37 58.5	118 38 53.8	Byrne	3,064.6
Dillon	32 28 53.47	1,646.9	91 7 1.71	44.6	321 24 3.3	141 24 31.9	Morancy	2,229.3
					277 52 26.2	97 53 32.1	Sand Island	3,232.2
Eagle	32 20 56.43	1,738.1	91 6 29.44	768.5	23 28 45.4	203 28 28.1	Dillon	2,114.8
					315 16 39.7	135 17 28.2	Sand Island	3,352.9

Creswell	32 20 53.90	1,660.3	91 7 32.67	853.7	[illegible]	[illegible]	[illegible]	[illegible]
					336 31 23.6	150 31 40.2	Dillon	2,020.4
Delta court-house, flag-staff at east end	32 19 6.08	187.3	90 56 13.41	350.7	307 38 53.7	127 39 47.4	Walnut	3,820.9
House near Walnut, chimney	32 18 1.69	52.1	90 54 32.39	847.4	354 20 23.8	174 26 30	Kemp	3,125.3
					64 17 37	244 16 40	Kemp	2,597.6
					207 10 8	27 10 55	Fort	5,002.2
Engine-house cupola, Delta	32 19 34.43	1,060.5	90 55.30.53	798.5	228 48 46	48 49 06	Northeast base	1,271.6
					332 32 44	152 33 15	Walnut	3,270.2
Vicksburg, Catholic church spire	32 20 54.63	1,682.8	90 52 54.68	1,429.6	25 33 48	205 32 56	Walnut	5,954.7
					74 54 27	254 52 20	Harris	6,444.2
Court-house cupola, Vicksburg	32 21 5.41	166.8	90 52 45.16	1,180.8	23 16 6	203 15 55	Fort	1,310.1
					92 2 7	272 1 37	Island	1,480.1
Trinity Church spire, Vicksburg	32 20 49.18	1,514.9	90 52 49.49	1,294	27 27 59	207 27 4	Walnut	5,865.3
					76 38 12	256 36 2	Harris	6,534.6
Methodist church spire, Vicksburg	32 20 52.15	1,606.4	90 52 46.41	1,293.5	27 44 58	207 44 1	Walnut	5,983.9
					76 1 49	255 59 37	Harris	6,634.7
McGee	32 23 3.23	99.6	90 52 57.11	1,492.7	18 3 55	198 3 31	Island	3,762.1
					355 4 44	175 4 50	Vicksburg court-house	3,642.6
National cemetery flag-staff	32 22 25.38	781.8	90 52 6.45	168.7	45 56 34	225 55 43	Island	3,460.6
					131 21 42	311 21 15	McGee	1,764.3
Mrs. King's house, chimney	32 20 37.15	1,144.4	90 56 36.86	963.0	292 7 31	112 8 26	Northeast base	2,905.5
					19 49 2	199 48 54	Harris	1,213.5
New house, south gable	32 21 12.24	377.1	90 57 38.86	1,016.1	23 17 7	203 16 57	Crane	1,205.6
					331 25 49	151 26 14	Harris	2,530.8
Waddell's house, southeast chimney	32 21 1.60	49.4	90 59 19.49	509.6	186 35 32	6 35 37	Yazoo	2,037.3
					326 13 46	146 13 53	Mattingly	650
Broozowski's (Dr.) house, chimney	32 23 41.46	1,277.1	91 00 55.48	1,449.9	340 49 20	160 49 45	Nichols	3,669.4
					3 42 19	183 43 17	Utz	1,184.4
Mayer's gin-house, chimney	32 24 46.82	1,442.3	91 1 .35	9.1	238 58 43	58 59 3	Pugh	1,141.3
					359 5 23	179 5 24	Utz	3,195.7
Graves's house, center	32 27 24.31	748.9	91 4 34.68	965.6	164 32 21	344 32 8	Sand Island	2,3[illegible]9.5
					241 41 58	61 42 37	Purvis	2,154.7
Milliken's Bend, church spire	32 27 30.88	951.2	91 6 7.63	190.4	220 25 53	40 26 29	Sand Island	2,759.8
					259 15 52	79 17 21	Purvis	4,401.3
Morency's house, northeast chimney	32 28 14.48	446	91 6 25.70	671.1	251 28 25	71 29 12	Sand Island	2,885.4
					141 57 23	321 57 4	Dillon	1,525.1
Omega	32 31 2.06	63.4	91 7 28.69	748.7	2 45 55.9	182 45 53.8	Creswell	3,104
					322 34 7.5	142 34 39.4	Eagle	2,548
Willows (Mississippi)	32 32 10.40	320.3	91 5 11.60	302.6	26 11 7.8	206 10 26	Eagle	4,600.5
					59 32 16.1	239 31 2.4	Omega	4,151.1
Terrapin	32 32 58.21	1,793	91 6 1.35	35.8	318 36 7.1	138 36 33.9	Willows	1,963
					32 30 26.3	212 29 38.3	Omega	4,242.1
Gynn (Mississippi)	32 34 11.08	341.3	91 4 34.11	889.7	14 44 48.1	194 44 28	Willows	3,843.8
					45 24 10.3	225 23 23.3	Terrapin	3,196.6

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Villa Vista	32 34 13.50	415.8	91 5 22.02	574.3	273 24 58.2	93 25 24	Gynn	1,252
					23 51 55.9	203 51 34.7	Terrapin	2,536.1
Henderson	32 35 .07	2.2	91 4 12.74	332.3	20 16 31.9	200 16 20.4	Gynn	1,608.7
					51 33 57	231 33 19.7	Villa Vista	2,307.2
Brunswick (Mississippi)	32 34 31.83	980.4	91 3 51.56	1,344.7	60 3 33.8	240 3 10.9	Gynn	1,230.7
					147 35 8.1	327 34 56.7	Henderson	1,030.3
Foster	32 36 1.69	52.1	91 3 14	365	19 29 37.9	199 29 17.7	Brunswick	2,936.1
					38 54 31.2	218 53 59.6	Henderson	2,439.2
Cabin Home (Mississippi)	32 35 24.87	766	91 2 13.60	354.5	57 24 44.1	237 23 51.3	Brunswick	3,032.5
					125 45 56.3	305 45 23.8	Foster	1,940.9
Albemarle (Mississippi)	32 37 14.10	434.2	91 2 .70	18.2	5 42 38.5	185 42 31.5	Cabin Home	3,381.4
					40 35 48	220 35 8.5	Foster	2,987.1
Newman	32 37 1.53	47.1	91 3 44.87	1,169.7	261 52 58.6	81 53 54.8	Albemarle	2,743.3
					336 24 18.7	156 24 35.3	Foster	2,011.5
Burleigh (Mississippi)	32 37 53.84	1,658.4	91 4 5.56	144.9	290 36 8.9	110 37 16.3	Albemarle	3,477.5
					341 29 41.3	161 29 52.5	Newman	1,699
Raleigh	32 36 56.27	1,733.2	91 5 56.39	1,522.1	238 54 22.7	58 55 23.5	Burleigh	3,434.8
					267 19 15.4	87 20 27.4	Newman	3,484.9
Tennessee (Mississippi)	32 37 50.06	1,542.6	91 6 11	286.7	267 57 38.3	87 58 46	Burleigh	3,272.1
					348 46 56.8	168 47 3.6	Raleigh	1,680.8
Edgewood	32 37 8.71	268.3	91 7 57.06	1,488	245 15 11.8	65 16 9	Tennessee	3,044.9
					277 3 9.8	97 4 13.8	Raleigh	3,118
No Place (Mississippi)	32 37 50.46	1,554.3	91 7 59.15	1,541.6	270 13 48.2	90 14 46.5	Tennessee	2,819.2
					357 35 49.7	177 35 50.8	Edgewood	1,287.1
Airlie	32 37 55.65	1,714.1	91 9 30.26	788.8	273 50 53.0	93 51 43	No Place	2,380.2
					300 45 30.8	120 46 21	Edgewood	2,826.8
Shoot (Mississippi)	32 38 15.41	474.6	91 8 37.55	978.7	307 31 37.8	127 31 58.5	No Place	1,261.9
					66 6 35.8	246 6 6.0	Airlie	1,502.8
Wilton	32 39 24.57	756.8	91 10 23.39	609.6	307 40 14.4	127 41 11.5	Shoot	3,485.6
					333 10 33.5	153 11 2.2	Airlie	3,060.4
Arcadia (Mississippi)	32 39 56.17	1,730.1	91 8 25.81	672.5	5 37 48.6	185 37 42.3	Shoot	3,118.9
					72 23 6.4	252 22 2.9	Wilton	3,215
Stamboul	32 40 31.33	965	91 9 54.43	1,417.0	295 7 11.3	115 7 59.2	Arcadia	2,550.5
					20 9 21.9	200 9 6.8	Wilton	2,190.5
Homestead	32 41 38.96	1,200.1	91 8 17.27	440.8	4 1 3.4	184 00 58.8	Arcadia	3,174.2
					50 32 55.0	230 31 8.4	Stamboul	3,278.3

Shiloh (Mississippi)	32 41 40.58	1,527.2	91 5 31.27	814.3	52 28 47.2	232 27 12.0	Arcadia	5,734.1
					85 41 16.3	265 39 46.6	Homestead	4,836.5
Concord	32 42 17.66	543.9	91 6 1.28	33.3	317 53 46.3	137 54 2.5	Shiloh	1,165.8
					71 24 42.8	251 23 28.9	Homestead	3,787.5
Bass	32 42 53.97	1,662.4	91 4 54.08	1,408.2	26 1 46.1	206 1 26	Shiloh	2,207.2
					57 25 24.6	237 24 48.3	Concord	2,076.9
Hays (Mississippi)	32 42 42.11	1,297.1	91 4 10.86	517.1	48 58 43.6	228 58 4.9	Shiloh	2,465.3
					112 17 4.2	292 16 45.7	Bass	963.1
Point Lookout	32 43 36	1,108.9	91 4 41.83	1,076.1	341 23 3	161 23 14.6	Hays	1,751.5
					14 23 7.7	194 23 .8	Bass	1,330.6
South 95 (Mississippi)	32 43 42.89	1,321.1	91 4 10.32	268.6	7 33 45.9	187 33 40.7	Hays	1,888.6
					75 16 32.2	255 16 15.4	Point Lookout	835
North 95 (Mississippi)	32 44 41.02	1,263.5	91 4 48.80	1,270.3	330 46 26	150 46 46.8	South 95	2,052
					354 27 26.4	174 27 30.4	Point Lookout	2,012.5
Deer	32 44 20.05	894.7	91 5 23.12	601.9	247 23 34.2	67 33 52.8	North 95	906.6
					326 20 36.9	146 20 59.5	Point Lookout	1,963.1
Farland (Mississippi)	32 45 .11	3.4	91 5 35.47	923.2	295 49 24.8	115 40 50	North 95	1,349.8
					341 25 30.2	161 25 36.9	Deer	1,009.6
Diamond	32 44 21.86	673.3	91 6 14.23	370.4	220 34 25.2	40 34 46.2	Farland	1,551.6
					260 32 51.6	80 33 22.3	Deer	1,319.2
Shipland (Mississippi)	32 44 52.53	1,618	91 7 14.16	368.6	264 47 44	84 48 37.4	Farland	2,579.9
					301 11 30.2	121 12 2.6	Diamond	1,824
Exern	32 43 53.73	1,655	91 8 27.68	720.6	226 34 32.5	46 35 12.3	Shipland	2,635.1
					255 59 17.6	76 00 29.8	Diamond	3,580.9
Ingersoll (Mississippi)	32 45 57.86	1,782.2	91 8 55.75	1,450.8	307 16 8	127 17 3	Shipland	3,323.2
					349 10 44.3	169 10 59.5	Exern	3,893.1
Wyly	32 45 24.16	744.1	91 10 5.91	153.8	240 22 41.3	60 23 19.3	Ingersoll	2,100.8
					317 26 18.2	137 27 11.4	Exern	3,781.6
Short	32 46 29.19	899.1	91 10 6.62	172.3	297 36 27.3	117 37 5.7	Ingersoll	2,031.8
					359 28 13.3	179 28 13.7	Wyly	2,003.2
Winslow	32 47 8.44	259.9	91 9 6.65	173	352 33 38.1	172 33 44	Ingersoll	2,192.4
					52 14 17.1	232 13 44.6	Short	1,274.2
Base, south end Lake Providence	32 47 12.12	373.3	91 10 21.35	555.5	273 20 17.7	93 20 58.2	Winslow	1,947
					343 50 26.9	163 50 34.9	Short	1,377
Base, north end Lake Providence	32 43 2.49	76.7	91 10 26.85	698.5	308 34 48.2	128 35 31.7	Winslow	2,669.7
					354 43 23.6	174 43 26.6	South base	1,558.12
Sand bar	32 35 3.73	114.9	91 3 14.56	379.6	85 45 16	265 44 45	Henderson	1,521.7
					180 27 56	00 27 56	Foster	1,785.4
Church spire	32 37 5.13	158	91 4 26.90	701.2	200 20 45	20 20 57	Burleigh	1,600.1
					275 46 33	95 46 56	Newman	1,101.3
Foster's chimney	32 36 57.97	1,785.6	91 5 8.19	213.5	223 29 28	43 30 2	Burleigh	2,372.3
					267 6 0	87 6 51	Newman	2,175
Foster's gin, cupola	32 36 49.75	1,532.4	91 5 5.21	135.8	98 14 40	278 14 17	Raleigh	1,400.9
					218 13 35	38 14 7	Burleigh	2,513.3

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Goodrich, Odd Fellows' Hall, north gable	32 37 41.51	1,278.6	91 00 14.05	366.1	222 19 58	42 20 18	Shoot	1,412.8
					296 43 20	116 44 2	Edgewood	2,246.5
Illawana post-office, chimney	32 38 24.19	745.1	91 9 2.19	57.1	276 58 55	96 59 40	Shoot	2,222.5
					316 34 11	136 34 28	Airlie	1,210.5
Melbourne, chimney	32 38 39.97	1,231.2	91 10 14.72	383.6	286 37 21	106 38 13		2,643.4
					310 40 04	139 40 28	Airlie	1,790.8
Wyly's house, east gable	32 45 23.44	722	91 10 26.13	680.3	245 43 58	65 44 47	Ingersoll	2,580.5
					311 51 20	131 52 24	Exern	4,140.9
Montgomery's house, cupola	32 45 55.01	1,694.4	91 10 9.12	237.3	267 21 53	87 22 35	Ingersoll	1,911.6
					324 44 24	144 45 19	Exern	4,575.2
Henderson gin, chimney	32 34 27.93	860.2	91 5 5.12	133.5	302 40 57	122 41 14	Gynn	961.1
					27 57 46	207 57 16	Terrapin	3,128.7
Cotton-gin, south gable	32 37 56.93	1,753.5	91 2 59.22	1,543.5	6 11 50	186 11 42	Foster	3,570.7
					34 54 06	214 53 41	Newman	2,080.5
Myer's store, south chimney	32 37 48.80	1,503.1	91 3 .16	4.2	38 40 53	218 40 31	......do	1,865.1
					95 12 19	275 11 44	Burleigh	1,711.7
Tennessee gin, chimney	32 38 12.62	388.7	91 6 9.67	252	300 6 38	120 07 56	Newman	4,363.8
					352 52 35	172 52 41	Raleigh	2,370.5
Powell's house, southwest chimney	32 42 58.34	1,797	91 3 59.76	1,556.1	46 18 58	226 18 47	Hays	723.7
					84 33 52	264 33 23	Base	1,420.9
Hall's store, west gable	32 43 10.68	328.9	91 3 49.89	1,299	72 53 30	252 52 55	......do	1,749.2
					120 13 00	300 12 32	Point Lookout	1,550.1
Sartoris	32 48 1.67	51.4	91 8 55.08	1,432.9	55 47 40.7	235 46 54	South base	2,714.8
					90 36 55.8	270 36 06.1	North base	2,387.9
Arlington	32 48 25.27	778.4	91 0 44.64	1,161.8	299 25 .9	119 23 27.7	Sartoris	1,460.8
					22 58 24.5	202 58 4.6	South base	2,447.3
Stack Island	32 49 33.32	1,026.8	91 7 50	1,300.4	30 57 0.5	210 56 34.2	Sartoris	3,292
					54 54 14.5	234 53 12.4	Arlington	3,645.1
Elton	32 50 1.32	40.7	91 8 42.65	1,109.1	302 12 8.8	122 12 37.8	Stack Island	1,018.2
					28 35 48	208 35 14.4	Arlington	3,369.5
Longwood	32 51 30.85	950.2	91 7 10.50	273	15 50 36.7	195 50 15.3	Stack Island	3,763.5
					40 59 25.9	220 58 35.0	Elton	3,653.0
Duncan	32 51 9.11	280.6	91 6 19.57	508.8	38 33 42.8	218 32 53.3	Stack Island	3,773.4
					116 40 54.0	296 40 27.8	Longwood	1,484
Vista	32 58 37.63	1,159.1	91 6 15.04	390.9	2 28 34.8	182 28 32.3	Duncan	2,729.3
					35 2 0	225 1 45.0	Longwood	2,012.1

Homochitto	32 52 12.27	377.9	91 5 26.26	692.5	35 28 20.2	215 27 51.3	Duncan	2,389.1
					121 37 45.0	301 37 19.1	Vista	1,480.4
Cottonwood	32 54 6.62	203.9	91 5 10.95	284.6	0 26 40.3	186 26 32	Homochitto	3,544.9
					31 17 10.1	211 16 41.3	Vista	3,207.9
Mayersville	32 54 20.22	622.8	91 4 8.53	221.7	27 8 40.4	207 7 58.2	Homochitto	4,428
					75 31 41.4	255 31 7.5	Cottonwood	1,675.3
Wilson's Point	32 56 3.14	96.7	91 5 20.33	528.1	329 31 21.7	149 32 .7	Mayersville	3,678.6
					356 6 56.6	176 7 3.7	Cottonwood	3,597.5
Green	32 56 7.07	217.8	91 4 38.54	1,001.1	340 40 21.0	160 40 37.9	Mayersville	3,582.6
					83 38 20.1	263 37 57.4	Wilson's Point	1,092.4
Duncansby	32 57 47	1,447.7	91 5 35.65	925.7	334 15 53.8	154 16 24.9	Green	3,417.3
					352 54 21	172 54 29.3	Wilson's Point	3,224.3
Possum Point	32 57 10.85	334.2	91 6 40.40	1,049.2	236 28 50.8	56 29 26	Duncansby	2,016.8
					301 49 13.1	121 50 19.4	Green	3,725.7
Williams	32 58 12.73	392.1	91 6 39.77	1,032.6	295 27 18.1	115 27 53	Duncansby	1,844.2
					0 29 17.8	180 29 17.5	Possum Point	1,906.4
Scott	32 57 41.44	1,276.5	91 8 .48	12.5	245 17 26.7	65 18 10.6	Williams	2,307.1
					294 21 48.4	114 22 32	Possum Point	2,283.4
Cordell	32 58 28.43	875.6	91 7 55.5	1,429.3	283 53 13.2	103 53 54.2	Williams	2,013.8
					5 33 32.3	185 33 29.3	Scott	1,451.5
Hardin	32 57 50.40	1,552.4	91 8 47.81	1,242.2	229 28 48.6	49 29 17.3	Cordell	1,803.3
					282 39 4.5	102 39 30.3	Scott	1,260.7
Lewis	32 58 27.35	842.4	91 9 13.76	357.4	269 03 31.0	89 4 17.4	Cordell	2,044
					329 24 16.6	149 24 30.7	Hardin	1,322.2
Pilcher's Point	32 57 43.94	1,353.5	91 11 25.28	656.4	248 36 34.9	68 37 40.5	Lewis	3,667.8
					267 12 7.8	87 13 33.5	Hardin	4,093.4
Sarah's Island	32 58 19.39	597.2	91 11 20.24	525.5	265 43 16.8	85 44 25.6	Lewis	3,293.5
					6 50 1.1	186 49 58.4	Pilcher's Point	1,099.8
Goza	32 57 58.55	1,803.5	91 12 51.92	1,348.2	254 54 18	74 55 7.9	Sarah's Island	2,465.8
					281 18 19.6	101 19 6.7	Pilcher's Point	2,294.7
Poverty Point	32 59 15.83	487.3	91 12 28.57	741.7	314 24 37	134 25 14.2	Sarah's Island	2,484
					14 17 26.8	194 17 11.1	Goza	2,436.3
Friedlander	32 58 54.92	1,691.6	91 13 25.38	658.9	246 24 34.9	66 25 5.8	Poverty Point	1,609.5
					333 24 37.0	153 24 55.8	Goza	1,941.6
Ashton	32 59 40.32	1,242.	91 13 .20	5.2	312 34 42.6	132 34 59.8	Poverty Point	1,115.1
					25 3 41.9	205 3 28.2	Friedlander	1,543.9
Stevenson	33 00 9.42	290.1	91 11 5.68	147.4	52 30 24.2	232 29 39.1	Poverty Point	2,712.3
					73 13 29.3	253 12 26.9	Ashton	3,105
Richardson	32 59 37.09	1,142.5	91 10 44.61	1,158	76 21 42.1	256 20 45.5	Poverty Point	2,777.4
					151 13 18.9	331 13 7.4	Stevenson	1,136.2
Graves	33 00 58.81	1,811.5	91 9 53.22	1,381.4	27 55 26	207 54 58	Richardson	2,849
					51 2 6	231 1 20.5	Stevenson	2,419.3
Carolina	33 00 37.13	1,143.7	91 9 12.36	320.8	52 19 34.9	232 18 44.7	Richardson	3,025.9
					122 11 56.2	302 11 33.9	Graves	1,253.3

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Kershaw	33 2 1.44	44.4	91 8 50	1,297.3	12 35 57.2	192 35 45	Carolina	2,661.2
					40 23 6.2	220 22 31.7	Graves	2,532.7
Sterling	33 2 2.89	89	91 9 36.32	941.4	272 7 58.9	92 8 24.2	Kershaw	1,207.8
					12 31 49	192 31 39.8	Graves	2,022.3
Bar	33 3 2.17	66.8	91 8 32.72	848.8	13 28 38.7	193 28 29.3	Kershaw	1,923.8
					42 6 36.8	222 6 2.1	Sterling	2,461.2
Raynor	33 3 59.84	1,843.3	91 9 34.36	891.2	318 00 12.8	138 00 46.4	Bar	2,300.4
					0 48 22.8	180 48 21.7	Sterling	3,602.9
Leota	33 4 27.98	861.9	91 8 54.46	1,412.4	347 57 19.1	167 57 31	Bar	2,703
					50 3 15.9	230 2 54.1	Raynor	1,350.2
Hilliard	33 4 54.70	1,685	91 10 5.42	140.5	294 5 19.3	114 5 58	Leota	2,016.1
					334 30 47.9	154 31 4.8	Raynor	1,872.1
Worthington	33 6 24.70	760.9	91 10 3.48	90.3	333 31 44.4	153 32 22.1	Leota	4,016.5
					1 2 13.5	181 2 12.4	Hilliard	2,773
Barnard	33 5 54.40	1,675.7	91 10 35.21	912.9	221 23 27.5	41 23 44.8	Worthington	1,244
					337 12 59.4	157 13 15.7	Hilliard	1,903
Moore	33 7 32.10	988.8	91 11 51.6	1,323.5	306 39 42	126 40 40.8	Worthington	3,477
					326 50 1	146 50 41.5	Barnard	3,593.2
Wickliffe	33 7 44.33	1,365.5	91 10 33.42	866.2	342 26 32.2	162 26 48.6	Worthington	2,573.2
					79 23 56.9	259 23 14.5	Moore	2,047.4
Haley	33 8 25.73	792.6	91 11 8.73	226.2	324 19 50.7	144 20 10	Wickliffe	1,569.7
					33 35 15.2	213 34 52.1	Moore	1,988.2
Cottage	33 8 6.06	186.7	91 9 26.41	684.5	68 56 6	248 55 24	Wickliffe	1,861.6
					102 52 41.1	282 51 45.2	Haley	2,720.6
Brooks	33 9 9	277.2	91 9 28.35	734.6	358 30 42.4	178 30 43.5	Cottage	1,939.5
					62 52 50.8	242 51 55.9	Haley	2,923.1
Ford	33 8 49.85	1,535.6	91 7 53.74	1,392.5	60 40 58.2	240 40 7.5	Cottage	2,754.7
					103 31 50.6	283 30 58.9	Brooks	2,521.8
Hill	33 8 11.60	357.3	91 7 52.24	1,353.8	86 00 20.3	265 50 28.8	Cottage	2,446.9
					178 6 7.6	358 6 6.8	Ford	1,179
Chaff	33 8 48.77	1,348.2	91 6 2.10	54.4	70 51 52.8	250 50 52.0	Hill	3,021.0
					93 42 57.8	273 41 56.8	Ford	2,890.4
Harwood	33 9 18.01	582.5	91 6 37.96	983.7	319 21 36.3	139 21 55.9	Chaff	1,426.8
					65 30 3.5	245 29 22.1	Ford	2,158.4
Hawkins	33 9 48.23	1,485.6	91 6 5.91	153.1	357 9 30.1	177 9 32.2	Chaff	1,988.4
					43 36 15.2	223 35 57.7	Harwood	1,227

Levee	33 9 26.63	820.3	91 5 11.49	297.7	44 48 58.4	224 48 30.7	Chaff	1,801.1
					116 16 18.8	296 16 48.5	Hawkins	1,550.8
Quarters	33 10 33.00	1,019.3	91 4 35.12	900.8	24 42 48.7	204 42 23.8	Levee	2,254
					59 34 10.8	239 33 21.1	Hawkins	2,728.1
Drift	33 10 27.90	850.4	91 5 26.45	685.2	263 8 27.1	83 8 55.2	Quarters	1,839.4
					348 23 26.7	168 23 34.9	Levee	1,927.2
Raft	33 11 42.42	1,306.7	91 5 34.81	901.5	324 5 41	144 6 13.7	Quarters	2,636.8
					354 36 40	174 36 53.6	Drift	2,805.9
Glenora	33 11 53.28	1,641.2	91 4 44.11	1,142.8	354 37 4.6	174 37 9.5	Quarters	2,481.3
					75 42 43.6	255 42 15.8	Raft	1,355.2
Adams	33 12 35.70	1,099.7	91 6 3.33	86.2	302 28 51.7	122 29 35.1	Glenora	2,432.6
					335 45 39.9	155 45 55.5	Raft	1,799.8
Sedge	33 12 8.10	252.2	91 5 42.62	1,103.3	326 42 13.8	146 42 45.9	Glenora	2,760.8
					28 11 7.2	208 10 55.9	Adams	1,135.8
Junction	33 13 20.01	616.4	91 7 .70	18.1	280.12 2.4	100 12 45.2	Sedge	2,054.5
					312 34 30.1	132 35 1.5	Adams	2,017.7
Walnut Point	33 14 8.83	272	91 6 50.71	1,312.8	316 38 58.8	136 39 36.1	Sedge	2,568.7
					9 45 43.2	189 45 37.7	Junction	1,526
Lakeport	33 13 37.43	1,152.9	91 7 31.09	804.9	227 13 15.4	47 13 37.5	Walnut Point	1,424.3
					304 17 47	124 18 3.6	Junction	952.4
Goose Bar	33 15 21.19	652.8	91 7 40.25	1,041.7	330 5 8.3	150 5 35.5	Walnut Point	2,571.7
					355 45 23.5	175 45 28.5	Lakeport	3,205.3
Compton	33 16 .59	18.2	91 6 51.26	1,326.5	359 45 47.8	179 45 47.6	Walnut Point	3,443
					46 15 13.5	226 14 46.6	Goose Bar	1,755.3
Starling	33 16 46.24	1,424.3	91 8 29.68	768	298 54 .8	118 54 54.8	Compton	2,909.6
					333 58 16.7	153 58 43.8	Goose Bar	2,916
Refuge	33 17 31.03	955.8	91 8 6.68	172.8	324 59 4.8	144 59 46.2	Compton	3,401.7
					23 20 29.5	203 20 16.9	Starling	1,502.6
Sunnyside	33 17 31.73	977.4	91 9 22.35	578.3	270 37 34.8	90 38 16.3	Refuge	1,958
					315 47 41.4	135 48 10.3	Starling	1,954.6
Island 84	33 18 50.03	1,818.3	91 9 25.70	664.7	322 58 25.8	142 59 9.2	Refuge	3,395.4
					358 9 5.4	178 9 7.2	Sunnyside	2,690.8
Davis	33 18 55.89	1,721.6	91 11 .65	16.8	267 44 33.1	87 45 25.3	Island 84	2,458
					315 32 47.7	135 33 41.7	Sunnyside	3,631.9
Warfield	33 20 16.41	505.5	91 9 33.52	866.6	355 8 .2	175 9 4.5	Island 84	2,392.6
					42 15 38.1	222 14 50.2	Davis	3,351.4
Vaucluse	33 20 27.64	851.4	91 10 32.78	847.5	282 43 16.1	102 43 48.7	Warfield	1,571
					14 18 34.5	194 18 19.2	Davis	2,917.1
Leland	33 21 41.85	1,289.1	91 9 9.44	244	18 18 31.9	193 18 21.7	Warfield	2,704.8
					43 18 43.8	2[illegible]3 17 58	Vaucluse	3,141.6
Highland	33 21 14.06	433	91 8 23.76	614.3	45 27 10.8	225 26 32.5	Warfield	2,531.4
					125 56 41.1	305 56 16	Leland	1,458.8
Halliday	33 22 26.22	807.7	91 7 48.58	1,255.5	22 15 19.6	202 15 .2	Highland	2,402
					56 49 42	236 48 57.5	Leland	2,497.7

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Richardson	33 21 46.29	1,425.9	91 6 30.37	785	71 17 46.9	251 16 44.5	Highland	3,095.8
					121 19 26.4	301 18 43.4	Halliday	2,366.6
Whittaker	33 22 57.68	1,776.7	91 6 47.74	1,233.7	348 27 40.6	168 27 50.2	Richardson	2,244.7
					58 21 27.2	238 20 53.7	Halliday	1,847.3
Jack	33 22 22.04	678.9	91 5 54.04	1,396.7	40 27 27.8	220 27 7.3	Richardson	1,447.3
					128 21 12.2	308 20 42.7	Whittaker	1,769.8
Bachelors' Bend Towhead	33 23 35.23	1,085.2	91 5 34.93	902.5	12 21 25.6	192 21 15.1	Jack	2,308.4
					58 25 16.2	238 24 36.1	Whittaker	2,208.9
Base, south end (Greenville)	33 23 18.19	560.4	91 4 32.44	838.4	50 38 50.1	230 38 5.2	Jack	2,728
					108 00 37.5	288 00 3.1	B. B. Towhead	1,698.3
Base, north end (Greenville)	33 24 19.23	592.4	91 3 58.77	1,518.4	61 23 53.6	241 23 .6	B. B. Towhead	2,830.7
					24 50 9.6	204 49 51.1	South Base	2,072
Telegraph	33 9 51.84	1,596.9	91 4 32.80	849.7	87 21 50	267 20 59	Hawkins	2,415.1
					177 17 13	357 17 12	Quarters	1,272.1
Point Chicot	33 24 44.14	1,359.6	91 5 24.84	641.7	289 1 51	109 2 38	Greenville, north base	2,352.6
					7 00 31	187 00 25	B. B. Towhead	2,138.8
Ben Lomond gin chimney	32 47 49.62	1,528.4	91 8 35.32	918.8	67 17 21	247 16 24	Lake Providence, south base.	2,991
					121 20 36	301 19 58	Arlington	2,111.5
Elton middle dormer window	32 49 58.44	1,800.1	91 9 7.30	189.8	262 7 12	82 7 25	Elton	647.6
					18 41 43	198 41 23	Arlington	3,029.6
Elton gin gable	32 50 8.90	274.1	91 8 59.17	1,538.7	298 30 17	118 30 26	Elton	489
					358 26 48	178 26 50	Sartoris	3,920.5
Duncannon gin ventilator	32 49 43.49	1,339.6	91 6 47.56	1,236.9	100 24 17	280 23 15	Elton	3,043.5
					169 46 20	349 46 8	Longwood	3,860.5
Duncannon gin chimney	32 50 22.44	691.2	91 6 18.74	487.3	57 29 18	237 28 20	Stack Island	2,815
					147 26 10	327 25 42	Longwood	2,500.4
Oakland gin chimney	32 50 46.72	1,439.1	91 6 .44	11.4	126 44 23	306 43 45	Longwood	2,278.1
					144 12 7	324 11 57	Duncan	850.4
Hollow Ridge Church spire (?)	32 51 15.68	482.9	91 5 48.01	1,248.3	102 17 54	282 17 9	Longwood	2,195.3
					164 26 45	344 26 30	Vista	2,620.4
Hollow Ridge gin chimney	32 51 30.18	929.5	91 5 16.07	417.8	90 24 29	270 23 27	Longwood	2,075.5
					143 34 48	323 34 16	Vista	2,582.2
Benham's southeast chimney	32 51 27.07	833.8	91 7 17.06	443.5	235 41 29	55 41 33	Longwood	206.6
					290 18 21	110 18 21	Duncan	1,594.1
Longwood gin chimney (?)	32 51 52.24	1,612.2	91 8 25.90	673.8	288 39 16	108 39 57	Longwood	2,009.0
					347 41 57	167 42 16	Stack Island	4,383.3

Vista gin chimney	32 53 11.34	849.8	91 6 53.72	1,896.5	231 8 52	51 9 18	Vista	1,291.2
					19 17 21	199 17 12	Longwood	1,821.2
McCullough's east chimney	32 53 10.92	836.8	91 5 54.92	1,427.5	337 34 48	157 35 4	Homochitto	1,954.1
					27 1 10	207 00 59	Vista	1,151.1
Cottonwood gin chimney (?)	32 53 16.30	502	91 6 5.50	143	332 38 53	152 39 14	Homochitto	2,220.6
					11 45 22	191 45 17	Vista	1,216.9
Mayersville warehouse, northwest gable (?)	32 54 .98	30.2	91 3 30.48	702.1	142 49 43	322 48 43	Wilson's Point	4,723.1
					154 58 26	334 57 18	Duncansby	7,084.8
River Light	32 55 28.31	871.9	91 4 14.88	386.6	355 30 10	175 30 13	Mayersville	2,103.8
					122 15 40	302 15 4	Wilson	2,010.6
Small house, west gable	32 55 27.65	851.6	91 4 14.52	377.2	355 43 9	175 43 12	Mayersville	2,082.9
					122 36 3	302 35 27	Wilson's	2,029.5
Dead tree (?)	32 55 29.50	908.6	91 5 12.44	323.2	217 15 30	37 15 48	Green	1,451.4
					322 0 41	142 7 10	Mayersville	2,703.9
Wilson's Point gin chimney	32 55 42.84	1,319.6	91 5 26.50	696.2	195 2 13	15 2 16	Wilson's Point	647.4
					230 13 43	59 14 9	Green	1,459
Grace's store, west gable	32 57 35.12	1,081.7	91 4 35.22	914.5	22 28 5	202 27 40	Wilson's Point	3,066.1
					103 8 17	283 7 44	Duncansby	1,611.5
Possum Point chimney	32 57 5.60	172.5	91 6 33.24	863.2	130 59 43	310 59 39	Possum Point	246.3
					229 32 40	49 33 11	Duncansby	1,965.4
Lewis's house chimney, north end	32 58 30.98	954	91 9 18.28	474.6	313 37 29	133 37 31	Lewis	162.1
					327 41 47	147 42 3	Hardin	1,479
Owen's store chimney (?)	32 57 40.03	1,233	91 11 24.89	646.3	175 13 56	355 13 56	Pilcher's Point	120.8
					185 41 25	5 41 28	Sarah's Island	1,218.3
Imboden's store chimney	32 59 28.44	876	91 13 9.57	218.4	213 37 47	33 37 52	Ashton	439.2
					290 3 54	110 4 16	Poverty Point	1,133.2
Carolina gin, northwest gable	33 00 39.45	1,215.2	91 9 5.19	134.7	69 1 19	249 1 15	Carolina	199.4
					115 34 6	295 33 40	Graves	1,882
Graves's store, northeast chimney	33 2 16.91	520.9	91 9 42.48	1,102.3	289 17 17	109 17 46	Kershaw	1,442.9
					339 40 57	159 41 00	Sterling	460.5
Hunting Lodge gin, river gable	33 3 15.94	491	91 9 48.94	1,269.6	195 37 28	15 37 36	Raynor	1,404.5
					282 6 1	102 6 43	Bar	2,022.5
Cracraft's gin, southeast gable	33 3 50.50	1,555.6	91 9 45.19	1,172.1	224 18 32	44 18 38	Raynor	402.2
					308 22 8	128 22 43	Bar	2,398.2
Hilliard's pigeon-house	33 4 50.91	1,568.2	91 10 6.37	165.2	290 44 13	110 44 52	Leota	1,994.4
					332 10 40	152 10 57	Raynor	1,778.9
Hilliard's store chimney	33 4 52.10	1,604.9	91 10 6	155.6	190 37 57	10 37 57	Hilliard	81.3
					332 59 34	152 59 51	Raynor	1,807.1
Worthington's balcony	33 5 21.84	672.8	91 9 15.06	390.6	57 22 33	237 22 6	Hilliard	1,550.9
					147 2 21	327 1 55	Worthington	2,807.9
Marengo gin chimney	33 5 54.88	1,690.5	91 11 29.28	757.9	247 32 57	67 33 44	Worthington	2,405.5
					270 36 5	90 36 35	Barnard	1,401.1
Hill's chimney	33 7 49.20	1,515.6	91 8 44.99	1,166	115 49 37	295 49 14	Cottage	1,192.7
					155 26 7	335 25 43	Brooks	2,703.1

Geographical positions between Greenville, Miss., and Donaldsonville, La.—Continued.

Name of station.	Latitude.	Seconds in meters.	Longitude.	Seconds in meters.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″		° ′ ″		° ′ ″	° ′ ″		*Meters.*
Harwood white house, southeast chimney	33 9 40.42	1,245	91 6 28.32	733.7	282 2 1	102 2 43	Levee	2,035.7
					338 43 17	158 43 31	Chaff	1,872.7
Harwood's store chimney	33 9 39.42	1,214.2	91 6 11.70	303.1	208 56 57	28 57 00	Hawkins	310.3
					284 10 18	104 10 51	Levee	1,609.4
Stella warehouse, gable	33 9 3.04	93.6	91 5 24.89	645	104 28 50	284 28 10	Harwood	1,955.8
					142 38 9	322 37 47	Hawkins	1,751.5
Longwood warehouse, gable	33 9 15.33	472.2	91 5 18.64	483	93 3 47	273 3 4	Harwood	2,058
					129 36 13	300 35 47	Hawkins	1,590.3
Longwood gin chimney	33 9 26.64	820.6	91 4 37.49	971.4	89 58 50	269 58 31	Levee	881.1
					188 53 32	8 53 35	Telegraph	786
Williams chimney	33 10 57.25	1,763.5	91 4 25.98	673	17 38 21	197 38 16	Quarters	780.9
					60 00 48	240 00 15	Drift	1,808.7
Glenora gin chimney	33 11 12.52	385.6	91 4 7.66	198.4	30 21 55	210 21 40	Quarters	1,407.4
					112 12 23	292 11 35	Raft	2,438.4
Refuge oil-works, cup (?)	33 17 20.80	640.7	91 7 55.66	1,440	39 35 [illegible]	219 35 11	Starling	1,381.5
					98 32 24	278 31 36	Sunnyside	2,268.1
Refuge post-office chimney	33 17 34.38	1,059	91 8 6.14	158.8	22 20 7	202 10 54	Starling	1,603.2
					87 38 00	267 37 18	Sunnyside	1,973.4
Shelby's south chimney	33 17 44.83	1,380.9	91 8 7.95	205.6	355 34 45	175 34 40	Refuge	426.4
					78 9 53	258 9 14	Sunnyside	1,966.8
Craig's gin chimney	33 22 19.57	602.9	91 8 34.82	900	351 56 22	171 56 28	Highland	2,038.5
					87 36 35	217 36 16	Leland	1,466.9
Episcopal Church spire, Greenville	33 24 40.21	1,238.6	91 3 57.30	1,480.4	3 21 51	183 21 50	North Base	647.4
					93 4 12	273 3 24	Port Chicot	2,265.1

A 4.

REPORTS ON FINAL REDUCTION OF DISCHARGE OBSERVATIONS ON THE MISSISSIPPI RIVER BETWEEN SEPTEMBER 30, 1884, AND APRIL 10, 1885, AT (*a*) POINT PLEASANT, MO., (*b*) HELENA, ARK., (*c*) ARKANSAS CITY, ARK., (*d*) WARRENTON, MISS., (*e*) RED RIVER LANDING, LA., (*f*) CARROLLTON, LA., WITH TABULATED RESULTS.

(*a*) POINT PLEASANT, MO.

SAINT LOUIS, *February* 10, 1887.

CAPTAIN: I have the honor to submit the following report upon the final reduction of discharge observations made on the Mississippi River at Point Pleasant, Mo., between September 30, 1884, and April 2, 1885.

The party at this station was under the direction of Assistant Engineer E. E. Haskell. Mr. C. Brainard acted as recorder throughout the season. A steam engineer and two boatmen completed the party.

Observations were made upon a section about four miles below Point Pleasant, Mo. The location of the section is well determined. At each end of the section, bases 500, 1,000 and 1,500 feet long were measured at right angles to the section. On each bank a series of radial signals were set, which intersected the section at points 200 feet apart, called velocity stations. A signal was also set on each bank for determining the river width. The distance between these latter signals prior to December 2, 1884, was 4,832 feet, but subsequent to that date it was 4,745 feet. Distances from the water's edges from these signals were observed each day and determined the river width.

Soundings were located at the velocity stations by the intersecting signals. Intermediate between these stations and between the end stations and the shores an irregular number of soundings were taken, but subsequent to November 1 the usual number between velocity stations was three, one for each 50 feet of width. Prior to January 1, 1885, a large number of the soundings were located by sextant angles to one of the several bases. On October 14, 15, 20, and 21, the locations were made by angles only. The locations by angles and by signals in the main are quite discrepant, and it has been found impossible to reconcile the two methods of location. The notes of the location of the signals have not been recorded or the computations of the same preserved, so that it is now impossible to prove that the signals were in the right places to make intersections 200 feet apart. On the other hand the sextant angles show discrepancies among themselves so that it is certain that the sextant angle locations are erroneous. There is also some evidence that the signal locations are erroneous, but as all velocity measurements and all soundings after January 1, 1886, were located by these signals alone, it was decided to reject the sextant angles entirely and depend upon the signals for location. Soundings between stations were assumed to be at equal distances apart, and where more or less than three soundings were taken between two stations, depths were interpolated from them corresponding to the middle and quarter points. Between the end stations and the shores the soundings were assumed to have been taken at equal distances apart and the end areas computed on that assumption. After December 3 a sounding between the end station and the shore was usually located by giving its distance from the shore.

The instruments in use at this station were Price meter No. 5, a break-circuit clock, electric batteries, transit, level, sextant, sounding leads and lines, etc. (The instruments and manner of using them were similar to those at Helena, which have already been described in my report upon reduction of work at that station.)

For determining the coefficients to be used in reducing the registrations of the meter to velocity in feet per second, four series of observations were made which have been reduced in the usual manner. In addition to these observations two series of observations were made by the U. S. Coast and Geodetic Survey, to whom this meter was loaned during the summer of 1885. The following table gives the results of the several series of observations:

Date.	No. of observations.	a	b	e_o	e_a	e_b	Remarks.
1884.							
Oct. 10	22	+4.023	+0.184	±0.054	±0.087	±0.108	In still water.
1885.							
Jan. 17	8	+4.216	+0.150	±0.093	±0.042	±0.087	Do.
Jan. 28	12	+4.072	+0.133	±0.228	±0.075	±0.122	Do.
Mar. 27	37	+4.035	+0.240	±0.436	±0.101	....	In running water.
July 17	22	+3.854	+0.209	±0.044	±0.014	±0.018	In still water, C. & G. S.
Sept. 19	25	+3.892	+0.232	±0.015	±0.015	±0.017	Do.

In the instructions governing this work the observers were required to note the time required for the meter-wheel to come to rest after being turned briskly with the hand. This was done at this station and the results are given in the following table:

Date.	Time.	Date.	Time.	Date.	Time.	Date.	Time.
	Sec.		*Sec.*		*Sec.*		*Sec.*
Oct. 22	99	Nov. 17	103	Dec. 9	135	Feb. 7	[illegible]
Oct. 23	100	Nov. 18	104	Dec. 10	136	Feb. 9	[illegible]
Oct. 24	98	Nov. 19	106	Dec. 12	137	Feb. 10	[illegible]
Oct. 25	98	Nov. 24	108	Dec. 13	138	Feb. 11	[illegible]
Oct. 27	98	Nov. 25	108	Dec. 15	134	Mar. 2	[illegible]
Oct. 29	98	Nov. 26	112	Dec. 31	140	Mar. 3	[illegible]
Oct. 30	99	Nov. 28	120	Jan. 12	80	Mar. 4	[illegible]
Oct. 31	101	Nov. 29	118	Jan. 13	80	Mar. 11	165
Nov. 3	100	Dec. 1	119	Jan. 14	80	Mar. 13	165
Nov. 5	98	Dec. 2	120	Feb. 2	80	Mar. 14	[illegible]
Nov. 10	103	Dec. 3	122	Feb. 3	78	Mar. 19	155
Nov. 14	105	Dec. 8	135	Feb. 5	170	Mar. 27	[illegible]

From this table it will be seen that the time required for the wheel to come to rest remained practically constant from October 22 to November 5, but from this date to December 31 there was a progressive change in the time. On January 12 the spring making the electric connection in the meter was broken and a new one put in, which materially changed the time. On February 5 the cup containing the electrical contact apparatus was filled with lard oil, again materially changing the time. Finally, on March 27, a new contact apparatus was put on, once again changing the time required for the wheel to come to rest.

Of the observations taken for rating the meter, those taken October 10 have been rejected on account of the range in velocities, 1.8 feet per second, being so small as to give the observations little weight. Those taken January 28 and March 27 have been rejected on account of the large errors of observation. Those taken January 17 have been retained and may be taken as determining the coefficients of the meter in its condition from January 12 to February 5, inclusive. It will be seen, however, that there are no observations that can be considered as determining the coefficients of the meter in its condition prior to January 12 or subsequent to February 5. If the length of time required for the meter to come to rest after being briskly turned with the hand is any criterion to judge by, then the meter materially changed its rate on both those dates, as it also did on March 27.

It was decided to reduce the observations, using as the coefficients of the meter the arithmetical means of the values obtained January 17, July 17, and September 19, which gave the equation,

$$y = + 3.987\,x + 0.197.$$

These values have been used throughout the entire series of observations. The difference between any discharge as computed with these values and as computed with any of the observed values would be in the same ratio as the difference of mean velocities, and the percentage of this difference may be shown in the following manner: The maximum observed mean velocity throughout the season corresponds to about 1.25 registrations per second of the meter, and the minimum observed mean velocity corresponds to about 0.72 registrations per second. Computing the values of y corresponding to $x = 1.25$ and $x = 0.72$ by the several equations, it will be found that the maximum change that would arise in any of the computed discharges from taking any of the observed ratings instead of the adopted one would be less than 5 per cent. of the total discharge. This difference of 5 per cent. can probably also be taken as the limit of the errors due to changes in the condition of the meter and the failure to properly determine the amount of those changes.

The soundings have been corrected in the note-books for errors in the lead line, but subsequent to November 19 no corrections were necessary. The section as sounded October 14, 15, 20, and 21 has been plotted by means of the sextant angles and depths scaled at points 50 feet apart and used in computing the areas for these dates. Beginning with October 22, the notes have been copied directly on the computation sheets, interpolating depths where more or less than three soundings were taken between two adjacent velocity stations. All soundings between the end stations and shores were used, the supposition being made that they were at equal distances apart. After all the areas between the end stations had been computed they were summed, and, with the end areas, gave the total water area of the section. This computation was then checked by computing the water area directly from the sum of the soundings.

The areas between the middle points of the divisions into which the section was divided by the velocity stations were then summed and called partial areas. The

sum of the areas between the shore and the middle point of the full division next the shore gave the partial area belonging to the velocity station next the shore. After December 8 an additional velocity was measured about 50 feet from each shore. These velocities were used with the areas out to a point half-way to the regular velocity station. The sum of the partial areas gave the total area and formed a check on the computation of the partial areas.

The counting of the registrations of the meter had been done in the field and the results were adopted in the office computation. The length of time of an observation for velocity varied from one to four minutes. The computation of the velocities from the given times and registrations was performed by means of a table prepared for the purpose. The measurements for velocity were uniformly taken at six-tenths the depth from the surface, and no coefficients have been applied to the observed velocities to reduce them to mean vertical velocities. A part of the velocities were measured with the launch at anchor, and part with the launch held in position by means of the wheel and rudder. The partial areas were multiplied by the corresponding velocities, giving the partial discharges. The sum of the partial discharges gave the total discharge per second.

The results of the computation at this stage were then copied into the tabulation accompanying this report. A gauge was established at the section, but was read only when observations were made for discharge. These readings are given in the tabulation, and correspond to the mean time of the observations. The zero of the gauge was 267.35 feet above Cairo datum plane. As the gauge was not regularly read, the change of stage in twenty-four hours could not be given in the table. In the place of this has been given the readings of the regular gauge at New Madrid (Morrison's Landing), about 14 miles above the discharge section. Until about January 7 the readings of these two gauges agree very closely, but on that date a difference between their readings of 1 foot appears, and for the remainder of the season the readings are quite discrepant.

The computation of datum areas has been made in the following manner: Datum was assumed to correspond with the gauge-reading, 27.77 feet, observed January 14, 1885. Datum width was taken as 4,698 feet. The slope of the banks was assumed to be uniform below the stage of 10 feet, between 10 and 20 feet, and between 20 and 27.77 feet. Width at stage of 10 feet was taken as 4,620 feet, and at stage of 20 feet was taken as 4,675 feet. Datum areas have then been computed by the following formulæ, w being the observed width and h observed gauge-reading.

Below 20 and 27.77 feet:

$$\text{Datum area} = (27.77 - h)\frac{4698 + w}{2} + \text{water area.}$$

Below 10 and 20 feet:

$$\text{Datum area} = (27.77 - 20)\frac{4698 + 4675}{2} + (20 - h)\frac{4675 + w}{2} + \text{water area.}$$

$$= 36{,}414 + (20 - h)\frac{4675 + w}{2} + \text{water area.}$$

Below 10 feet:

$$\text{Datum area} = 36{,}414 + (20 - 10)\frac{4675 + 4620}{2} + (10 - h)\frac{4620 + w}{2} + \text{water area.}$$

$$= 82{,}889 + (10 - h)\frac{4620 + w}{2} + \text{water area.}$$

On December 9, 10, and 11 a bar appeared above water near the right bank, and the portion between the bar and shore was not sounded. The area of this portion on those dates has been computed from the soundings of December 8, corrected for change of stage, and added to the datum areas on those dates. The amounts added were 705, 632, and 705 square feet for December 9, 10, and 11, respectively. In the early part of the work some very large changes took place in datum areas, and in such a manner as to place in doubt the measurements of areas at that time.

Mean depth has been obtained by dividing the water area by the width, and mean datum depth by dividing the datum area by the datum width. Maximum depth has been taken directly from the soundings. Scour and fill has been obtained by taking differences of datum areas, scour being indicated by the positive sign. Mean velocity has been obtained by dividing the discharge by the water area. The direction and force of the wind has been given as noted by the observer.

A number of slope observations were made by reading gauges on each bank approximately ½ mile above and below the section. The observations have been reduced, but the results are very discrepant, and have been rejected.

Accompanying this report is a plate on which are plotted the mean velocities, areas, and discharges, as abscissas to gauge heights as ordinates, the scale for each system of co-ordinates being given on the plate. The gauge readings and datum areas have been plotted on the plate in chronological order, but to make the gauge curve com-

plete readings at New Madrid, or at Point Pleasant, have been used when no reading were taken at the section. The section, as sounded January 14, 1885, is also show on the plate.

The gauge-readings, areas, datum areas, mean velocities, and discharges have als been plotted in chronological order on another plate for purpose of inspection an study. The scale is too large to admit of reproduction of the plate.

Very respectfully, your obedient servant,

L. L. WHEELER,
In charge Computing Division.

Capt. THOMAS TURTLE,
Corps of Engineers U. S. Army,
Secretary Mississippi River Commission.

Discharge observations at Point Pleasant, Mo.

Date.	Gauge-reading.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	At section.	At New Madrid.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1884.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu. ft.*	
Oct. 1	......	......	......	......	......	......	......	......	......	......	......	
2	......	......	......	......	......	......	......	......	......	......	......	
3	......	......	......	......	......	......	......	......	......	......	......	
4	......	......	......	......	......	......	......	......	......	......	......	
5	......	......	......	......	......	......	......	......	......	......	......	
6	......	......	......	......	......	......	......	......	......	......	......	
7	......	......	......	......	......	......	......	......	......	......	......	
8	......	......	......	......	......	......	......	......	......	......	......	
9	......	......	......	......	......	......	......	......	......	......	......	
10	......	......	......	......	......	......	......	......	......	......	......	
11	......	......	......	......	......	......	......	......	......	......	......	
12	......	......	......	......	......	......	......	......	......	......	......	
13	......	......	......	......	......	......	......	......	......	......	......	
14	12.97	12.75	106,577	175,659	23.0	37.4	35.0	4,619	......	3.675	391,655	Down, strong.
15	13.30	13.12	101,623	169,192	22.0	36.0	35.0	4,625	− 6,467	3.487	354,309	Up, brisk.
16	......	13.32	......	......	......	......	......	......	......	......	......	
17	......	13.48	......	......	......	......	......	......	......	......	......	
18	......	13.50	......	......	......	......	......	......	......	......	......	
19	......	13.15	......	......	......	......	......	......	......	......	......	
20	13.00	12.90	96,880	165,837	21.0	35.3	36.0	4,623	− 3,355	......	......	Up, brisk.
21	12.66	12.55	96,820	167,350	21.0	35.6	33.5	4,621	+ 1,513	......	......	Up, brisk.
22	12.32	12.22	96,768	168,867	21.0	35.9	34.0	4,618	+ 1,517	3.616	349,878	Down, sharp.
23	11.95	11.95	95,377	169,191	20.7	36.0	33.5	4,617	+ 324	3.686	351,512	Down, sharp.
24	11.65	11.70	101,316	176,516	21.9	37.6	34.0	4,615	+ 7,325	3.411	345,551	Up.
25	11.35	11.35	101,016	177,605	21.9	37.8	34.0	4,614	+ 1,089	3.409	344,354	Up, slight.
26	......	11.20	......	......	......	......	......	......	......	......	......	
27	11.53	11.58	104,872	180,659	22.7	38.5	35.0	4,622	+ 3,054	3.444	361,221	Down.
28	......	11.86	......	......	......	......	......	......	......	......	......	
29	11.87	11.90	93,612	167,822	20.2	35.7	34.8	4,623	−12,837	3.701	346,448	Down, slight.
30	11.76	11.74	103,219	177,937	22.3	37.9	37.2	4,622	+10,115	3.424	353,432	SW., slight.
31	11.59	11.54	91,934	167,442	19.9	35.6	32.2	4,622	−10,495	3.628	333,512	Calm.
Nov. 1	......	11.34	......	......	......	......	......	......	......	......	......	
2	......	11.17	......	......	......	......	......	......	......	......	......	
3	11.03	10.90	88,722	166,802	19.2	35.5	32.4	4,615	− 610	3.668	325,417	Calm.
4	......	10.50	......	......	......	......	......	......	......	......	......	
5	10.13	10.10	83,814	166,070	18.2	35.3	32.9	4,608	− 732	3.514	294,626	Down.
6	......	9.69	......	......	......	......	......	......	......	......	......	
7	......	9.24	......	......	......	......	......	......	......	......	......	
8	......	8.86	......	......	......	......	......	......	......	......	......	
9	......	8.52	......	......	......	......	......	......	......	......	......	
10	8.27	8.26	75,150	166,011	16.4	35.3	30.6	4,596	− 59	3.330	250,268	Up, slight.
11	7.92	7.92	73,136	165,606	15.9	35.3	30.3	4,593	− 405	3.146	230,064	Calm.
12	......	7.61	......	......	......	......	......	......	......	......	......	
13	......	7.33	......	......	......	......	......	......	......	......	......	
14	6.99	7.08	69,124	165,871	15.1	35.3	28.4	4,588	+ 265	3.384	233,949	
15	......	6.80	......	......	......	......	......	......	......	......	......	
16	......	6.68	......	......	......	......	......	......	......	......	......	
17	6.51	6.60	67,151	166,104	14.6	35.4	28.1	4,586	+ 233	3.259	218,858	
18	6.52	6.62	66,943	165,850	14.6	35.3	28.5	4,586	− 254	3.193	213,758	Down, strong.
19	6.50	6.60	65,968	164,967	14.4	35.1	30.5	4,586	− 883	3.163	208,631	
20	......	6.56	......	......	......	......	......	......	......	......	......	
21	......	6.44	......	......	......	......	......	......	......	......	......	
22	......	6.29	......	......	......	......	......	......	......	......	......	

Discharge observations at Point Pleasant, Mo.—Continued.

Date.	Gauge-reading.		Dimensions of cross-section of discharge.									
			Area.		Depth.							
	At section.	At New Madrid.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
1884.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu. ft.*	
Nov. 23		6.18										
24	5.83	6.08	62,609	164,680	13.7	35.0	28.0	4,583	— 281	3.181	199,173	Up, slight.
25	5.69	6.00	62,956	165,671	13.7	35.3	27.5	4,580	+ 985	3.186	200,562	
26	5.70	6.12	63,218	165,887	13.8	35.3	27.5	4,580	+ 216	3.155	199,464	West, strong.
27		6.70										
28	7.25	7.52	69,246	164,806	15.1	35.1	29.0	4,595	— 1,081	3.316	229,596	Down, strong.
29	7.65	7.92	71,018	164,738	15.4	35.1	29.5	4,598	— 68	3.305	234,717	
30		8.00										
Dec. 1	7.65	7.85	70,837	164,557	15.4	35.0	29.5	4,598	— 181	3.334	236,179	Up, slight.
2	7.49	7.60	70,815	165,286	15.4	35.2	29.5	4,609	+ 729	3.247	229,951	Up, slight.
3	7.15	7.25	68,870	164,911	15.0	35.1	29.0	4,603	— 375	3.344	230,316	
4	6.66	6.75	66,646	164,929	14.5	35.1	29.0	4,598	+ 18	3.272	218,180	Up, brisk.
5	6.12	6.13	63,455	164,219	13.8	34.9	28.0	4,504	— 710	3.237	205,435	Up, slight.
6		5.60										
7		4.89										
8	4.56	4.46	56,139	164,038	12.3	34.9	26.5	4,575	— 181	3.098	173,950	Calm.
9	4.17	4.10	53,068	163,465	12.6	34.8	25.5	4,225	— 573	3.088	163,877	Calm.
10	3.94	3.95	52,650	164,032	12.6	34.9	25.0	4,184	+ 567	3.144	165,556	
11	4.15	4.29	53,170	163,659	12.6	34.8	25.5	4,225	— 373	3.217	171,069	NE., slight.
12	5.00	5.10	57,348	163,237	12.5	34.7	26.5	4,580	— 422	3.223	184,834	Down, strong.
13	6.26	6.25	63,935	164,062	13.9	34.9	27.0	4,598	+ 825	3.301	211,073	N., slight.
14		7.25										
15	8.01	8.25	71,936	164,012	15.6	34.9	29.0	4,613	— 50	3.291	236,750	NE., light.
16	9.02	9.25	78,051	165,467	16.9	35.2	30.0	4,619	+1,455	3.503	273,389	Up, brisk.
17		10.10										
18		10.58										
19		10.78										
20		10.79										
21		10.55										
22		9.70										
23		9.15										
24		8.55										
25		8.02										
26		7.88										
27		8.55										
28		10.20										
29		12.65										
30		14.90										
31	17.45	17.50	114,195	162,512	24.5	34.6	39.0	4,661	—2,955	4.404	502,908	Down, strong.
1865.												
Jan. 1	19.98	19.90	126,615	163,122	27.1	34.7	40.0	4,675	+ 610	4.841	612,987	Down, strong.
2		21.70										
3		22.28										
4		22.45										
5		22.15										
6		21.95										
7	23.34	22.38	143,943	164,735	30.7	35.1	42.0	4,689	+1,613	4.947	712,038	S., brisk.
8	23.61	22.68	145,958	165,483	31.1	35.2	43.0	4,689	+ 748	4.868	710,556	S., brisk.
9	24.05	23.15	147,615	165,075	31.5	35.1	43.0	4,689	— 408	5.086	750,701	Down, strong.
10	24.95	24.10	153,305	166,543	32.7	35.5	44.0	4,691	+1,468	5.001	766,672	S., breeze.
11		25.18										
12	26.92	25.95	158,744	162,737	33.8	34.6	45.0	4,698	—3,806			
13	27.63	26.26	157,873	158,531	33.6	33.7	46.0	4,698	—4,206	5.168	815,839	Down, slight.
14	27.77	26.46	162,149	162,149	34.5	34.5	46.5	4,698	+3,618	5.193	842,106	Up, slight.
15		26.50										
16		26.60										
17		27.20										
18		28.15										
19		28.68										
20		29.40										
21		30.20										
22		30.83										
23		31.15										
24		31.32										
25		31.37										
26		31.42										
27		31.26										
28		30.65										
29		28.75										
30		26.32										
31		23.62										

Discharge observations at Point Pleasant, Mo.—Continued.

Date.	Gauge-reading.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	At section.	At New Madrid.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1885.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu. ft.*	
Feb. 1	......	21.15	......	......	......	......	......	......	......	......	......	
2	21.29	19.82	121,396	151,720	26.0	32.3	38.0	4,663	−10,423	4.619	560,778	S., slight.
3	19.98	18.30	115,184	151,691	24.7	32.3	38.0	4,665	− 35	4.423	509,440	S., brisk.
4	......	17.35	......	......	......	......	......	......	......	......	......	
5	......	17.27	......	......	......	......	......	......	......	......	......	
6	......	17.05	......	......	......	......	......	......	......	......	......	
7	17.80	17.07	104,700	151,386	22.4	32.2	35.0	4,66[illegible]	− 305	......	......	
8	......	17.45	......	......	......	......	......	......	......	......	......	
9	18.51	17.85	106,782	150,160	22.9	32.0	36.0	4,672	− 1,226	4.538	484,622	Down, heavy.
10	18.97	18.27	110,091	151,327	23.5	32.2	36.0	4,689	+ 1,167	4.512	496,782	Down, strong
11	19.34	18.75	114,654	154,158	24.4	32.8	36.0	4,689	+ 2,831	4.447	509,826	Up, slight.
12	......	19.30	......	......	......	......	......	......	......	......	......	
13	......	19.90	......	......	......	......	......	......	......	......	......	
14	......	20.50	......	......	......	......	......	......	......	......	......	
15	......	21.05	......	......	......	......	......	......	......	......	......	
16	......	21.34	......	......	......	......	......	......	......	......	......	
17	......	21.26	......	......	......	......	......	......	......	......	......	
18	......	20.58	......	......	......	......	......	......	......	......	......	
19	......	19.80	......	......	......	......	......	......	......	......	......	
20	......	18.75	......	......	......	......	......	......	......	......	......	
21	......	17.32	......	......	......	......	......	......	......	......	......	
22	......	16.28	......	......	......	......	......	......	......	......	......	
23	......	15.25	......	......	......	......	......	......	......	......	......	
24	......	14.65	......	......	......	......	......	......	......	......	......	
25	......	14.36	......	......	......	......	......	......	......	......	......	
26	......	13.90	......	......	......	......	......	......	......	......	......	
27	......	13.60	......	......	......	......	......	......	......	......	......	
28	......	13.40	......	......	......	......	......	......	......	......	......	
Mar. 1	......	13.20	......	......	......	......	......	......	......	......	......	
2	11.37	13.00	84,992	161,527	18.4	34.4	29.0	4,623	+7,369	3.683	312,993	S., slight.
3	11.76	12.82	85.960	160,690	18.6	34.2	27.0	4,625	− 837	3.708	318,714	Calm.
4	12.58	12.90	90.122	161,058	19.5	34.8	28.0	4,630	+ 368	3.873	349,044	Calm.
5	......	13.48	......	......	......	......	......	......	......	......	......	
6	......	14.18	......	......	......	......	......	......	......	......	......	
7	15.34	15.15	104,139	162,287	22.4	34.5	30.0	4,653	+1,229	4.065	423,305	Down, brisk.
8	......	16.72	......	......	......	......	......	......	......	......	......	
9	18.70	18.25	119,566	162,054	25.6	34.5	35.5	4,669	− 233	4.265	509,906	S., brisk.
10	20.55	19.91	127,695	161,539	27.3	34.4	35.5	4,677	− 515	4.225	539,481	S., brisk.
11	22.01	21.05	140,418	167,447	30.0	35.6	40.0	4,687	+5,908	4.356	611,606	S., slight.
12	......	21.46	......	......	......	......	......	......	......	......	......	
13	22.82	21.61	146,531	169,771	31.2	36.1	42.0	4,692	+2,324	4.455	652,841	Calm.
14	23.26	22.18	149,186	170,360	31.8	36.3	42.0	4,692	+ 589	4.372	652,179	S., brisk.
15	......	23.14	......	......	......	......	......	......	......	......	......	
16	......	23.89	......	......	......	......	......	......	......	......	......	
17	......	24.50	......	......	......	......	......	......	......	......	......	
18	......	25.08	......	......	......	......	......	......	......	......	......	
19	26.60	25.05	166,305	171,802	35.4	36.6	46.0	4,699	+1,442	4.885	812,467	N., brisk.
20	26.30	24.68	163,334	170,241	34.7	36.2	43.0	4,699	−1,561	4.769	778,901	Calm.
21	26.09	24.46	166,095	173,988	35.4	37.0	43.0	4,699	+3,747	4.787	795,155	Calm.
22	......	24.16	......	......	......	......	......	......	......	......	......	
23	25.46	23.88	160,069	170,923	34.1	36.4	42.0	4,699	−3,065	4.520	723,492	Calm.
24	24.96	23.38	157,497	170,701	33.5	36.3	42.0	4,700	− 222	4.421	696,295	Calm.
25	......	22.76	......	......	......	......	......	......	......	......	......	
26	......	21.86	......	......	......	......	......	......	......	......	......	
27	......	20.82	......	......	......	......	......	......	......	......	......	
28	21.55	19.80	137,892	167,067	29.5	35.6	38.0	4,683	−3,634	4.875	698,333	Down, strong.
29	......	18.78	......	......	......	......	......	......	......	......	......	
30	19.06	17.88	126,182	166,903	27.0	35.5	36.0	4,680	− .74	4.061	512,421	S., strong.
31	18.27	16.99	118,980	163,477	25.5	34.8	34.5	4,669	−3,516	4.041	480,760	S., slight.

(*b*) HELENA, ARKANSAS.

SAINT LOUIS, *November* 19, 1885.

CAPTAIN: I have the honor to submit the following report upon the final reduction of discharge observations made on the Mississippi River at Helena, Ark., between October 1, 1884, and April 10, 1885:

The party at this station took the field under the direction of Assistant Engineer J. C. Quintus, but before the work was fairly inaugurated he resigned. Assistant

Engineer A. H. Weber took charge of the party October 10 and remained in charge to the end of the season. Mr. C. W. Stewart acted as recorder throughout the season. A steam engineer and two boatmen completed the party.

Observations at this station were made upon two sections about three-quarters of a mile apart. The first one, called the high-water section, was a short distance below the elevator, and if prolonged would nearly pass through the triangulation station Helena. The high-water section was not quite identical with the section used in 1882. The two sections had a common point on the left bank, but the high-water section at the right bank was about 200 feet above the section used in 1882. It was located by Mr. Quintus, who measured a 1,200-foot base and set a system of ranges which intersected the section at intervals of 300 feet. Subsequently Mr. Weber discovered that an error had been made in measuring this base and that its real length was 1,194 feet. This error, with changes in the measured angles, reduced the intervals into which the section was divided from 300 feet to 297.85 feet. The ends of the section were marked by range signals, the one on the right bank being at the upper end of the base line and called U. B. The one on the left bank was called A. The distance from U. B. to A. was 4,794.8 feet. The points where the ranges intersected the section were called stations, velocities being observed at those points. The stations were numbered from the right bank, station 1 being 62.6 feet from U. B., and station 16, 264.2 feet from A.

In the system of intersecting ranges the pivot signal was 3,542.5 feet above the section and a perpendicular from it intersected the section 360 feet from U. B. The other signals were beyond the pivot at such distances as would give good ranges. The minimum angle for locating a point on the section with this set of signals was 38° 37′. Between the signals locating the velocity stations secondary signals were set to intersect the section midway between the velocity stations. By bisecting the intervals between signals, the distance between velocity stations could be divided into four equal parts, and soundings were taken at all these points with few exceptions.

As the lower stages of the river were reached in November, several undesirable features developed in the high-water section. The water for about 1,200 feet out from the left bank became too shallow to allow the launch to be used. The presence of the bar just below, and reaching up to the section, caused the water to be deflected toward the right bank, the current in the middle of the section being no longer normal to the section. As the water continued to fall the bar appeared above water and formed a pocket along the left bank, in which there was no current.

It was decided therefore to change the section, and a low-water section was located about three-quarters of a mile above the high-water section. This section proved a very satisfactory one and was used until January 7, when observations were resumed at the high-water section. The manner of locating velocity stations and soundings was similar to that already described for the high-water section. The points marking the ends of the section were designated U¹. B¹. and A¹, and the distance between them was 4,502.6 feet. The pivot signal was 2,966.8 feet above the section and a perpendicular from it intersected the section 568.5 feet from U¹. B¹. The signals were set to locate velocity stations 200 feet apart and soundings 50 feet apart. Station 1 was 168.5 feet from U¹.B¹, and station 22, 134 feet from A¹. The signals were located by angles from a 1,000-foot base at right angles to the section and downstream from U¹. B¹. The minimum angle for locating points on the section was 37° 1′.

As the river rose in January, the low-water section became unsuitable on account of the water passing back of the towhead down Helena Chute. On January 7 the measured chute discharge was 3,539 cubic feet per second, and this amount would rapidly increase with the stage.

On returning to the high-water section, the old set of signals were used until January 13, when a new set of signals, intersecting the section at intervals of 200 feet, came into use. A new point on the section 36.5 feet back of U. B. was taken for U. B. The pivot signal was 7,133.7 feet above the section and a perpendicular from it intersected the section 1,569.8 feet from U. B. Station 1 was 169.8 feet from U. B. and station 24, 61.5 feet from A. The distance from U. B. to A. was 4,831.3 feet. This section and set of signals were used until the end of the observations. The minimum angle for locating a point on the section was 65° 25′.

The distances of the water edges from the end signals were determined each day, and determined the river width. To facilitate the measurement of these distances stakes were set at intervals between the end signals and the water edge.

The accompanying sketch on a scale of 1:10,000 shows the location of the sections. The soundings shown on the sketch were taken December 1, 1883, and are given to show the general shape of the bed at this station.

The instruments in use at this station consisted of Price meter No. 10, a Morse register, a break-circuit clock, electric batteries, transit, level, sextant, sounding leads and lines, etc.

The meter was made under the direction of Mr. W. G. Price, the inventor. It is of the anemometer type and does not differ in principle from the Ellis meters previously

in use on the river. Each revolution of the wheel makes and breaks an electric circuit, the contact being made directly on the upper end of the vertical axis of the wheel, which is incased in a small box. The contact apparatus gave considerable trouble by the separation of the parts of which it is composed. The meter is much larger and stronger than the Ellis meter, and is so constructed as to be free to swing in both vertical and horizontal directions. The bearings and contact apparatus are protected from the water by inclosing them in air-tight chambers.

The Morse register is of the usual form, except that an additional armature and registering point has been added, both points making indentations on the same paper ribbon. One of the registering points was used to register the revolutions of the meter and the other the beats of the clock. As the circuit was closed during half a revolution of the meter and open the remaining half, the meter record appeared on the paper as a series of dashes separated by spaces equal to their length. The clock closed and opened an electric current each half second. Every seven and a half seconds, however, one beat was omitted, thus making the time record consist of a series of fourteen short dashes and spaces, the different series being separated by longer spaces. The two registering points were so arranged that simultaneous registrations appeared opposite each other on the ribbon and about three-eighth inch apart. The record of an observation for velocity, therefore, was complete at any instant and an observation could be taken as extending over any portion of the record.

The batteries used were of the Leclanché type, four cells being used on the meter circuit and two on the clock circuit. The current between the clock, register, and battery was made in the usual manner and needs no description. The meter circuit was made by attaching one pole of the battery to the steel sash cord on which the meter was suspended, the current passing through the frame of the meter and contact apparatus to the insulated guy line, thence completing the circuit back to the battery through the register.

A 12-pound sounding lead was used until January 10, when it was lost and a 15-pound lead substituted in its place, which was used to the end of the season. A $\frac{1}{4}$-inch Italian hemp line was used throughout the season. Drifting soundings were taken as a general rule in the deep and swift water, but in water less than 20 feet deep soundings were obtained without drifting. During low water the whole section was sometimes sounded without drifting, but this was seldom done.

The entire plant was worked from an open iron launch 45 feet long, 7 feet beam, and $4\frac{1}{2}$ feet draught. The meter was suspended from a boom 12 feet long at the stern of the launch, the boom projecting over the side and making an angle of about 45° down-stream with the axis of the launch. A steel sash cord, three-sixteenth inch in diameter, passed around a reel in the stern of the launch, through a small pulley in the end of the boom, thence to an iron rod 1 inch in diameter and 2 feet long. To this rod the meter was attached, and also a lead weight of about 50 pounds. Attached to the top of the rod was an insulated guy rope, which passed through a pulley in the end of a 20-foot boom in the bow of the launch and thence to a reel. By paying out proper lengths of the standing and guy lines, the meter could be immersed to any desired depth. In measuring the velocities the launch was anchored when it was safe to do so, but when not, it was held in position by the engine and rudder.

In reducing the observations, the coefficients to be used in reducing registrations of the meter to velocity in feet per second were first determined. Observations for determining the coefficients of the meter were made by causing the meter to move through still water over known distances at various velocities, the time and number of registrations being noted.

If we let B = known distance in feet;

t = time in seconds occupied in moving over B;

r = number of registrations in time t;

Then, $x = \frac{r}{t}$ = number of registrations per second;

And,

$y = \frac{B}{t}$ = velocity in feet per second of meter through the water.

The observations have been reduced on the assumption that the relation between the variables is expressed by the equation

$$y = ax + b$$

a and b being constants to be determined.

In reducing the observations, the mean of all the observation equations was taken and subtracted from each, making the observation equations of the form

$$a(x - x_0) - (y - y_0) = v$$

x_0 and y_0 being the mean values of x and y respectively.

The formation and solution of the normal equations and the computation of the mean errors were then made in the usual manner and checked by a suitable control or by duplication. The following table contains the results of the observations for rating the meter at this station, the mean errors of observation and of the determination of the constants:

Date.	No. of observations.	*a*.	*b*.	Mean error of observations.	Mean error of *a*.	Mean error of *b*.
Oct. 7, 1884	24	+4.093	+0.091	±0.071	±0.035	±0.034
Oct. 17, 1884	17	+3.802	+0.263	±0.120	±0.080	±0.074
Oct. 24, 1884	15	+4.017	+0.206	±0.094	±0.062	±0.060
Nov. 5, 1884	20	+4.090	+0.134	±0.070	±0.042	±0.036
Dec. 3, 1884	20	+3.954	+0.350	±0.087	±0.041	±0.040
Jan. 3, 1885	10	+4.016	+0.175	±0.068	±0.036	±0.043

For reducing the observed velocities in the discharge measurements, the arithmetical mean of the values *a* and *b* have been adopted and the equation between the variables becomes

$$y = 3.995\,x + 0.203.$$

These values have been used throughout the entire series of observations, the impossibility of determining the period over which each rating should be used making this course necessary. The difference between any discharge as computed by any of the observed ratings would be in the same ratio as the difference of mean velocities, and the percentage of this difference may be shown in the following manner. The maximum mean velocity throughout the season corresponds to about 1.18 revolutions per second of the meter and the average of the mean velocities for the season corresponds to about 0.90 revolutions per second. Computing the values of y corresponding to $x=1.18$ and $x=0.90$ by the several ratings and by the adopted rating, we obtain the values in the following table, v representing the difference between the velocity, y, as computed by an observed rating and y_0, as computed by the adopted one.

Date.	$x = 1.18$		$x = 0.090$	
	y.	*v*.	*y*.	*v*.
Oct. 7, 1884	4.921	+0.004	3.775	−0.024
Oct. 17, 1884	4.749	−0.168	3.685	−0.114
Oct. 24, 1884	4.946	+0.029	3.821	+0.022
Nov. 5, 1884	4.960	+0.043	3.815	+0.016
Dec. 3, 1884	5.016	+0.099	3.909	+0 110
Jan. 3, 1885	4.914	−0.003	2.780	−0.010
Adopted	4.917		3.769	

The maximum value of the ratio $\frac{v}{y_0}$, for $x = 1.18$ is 0.034

and the average value without regard to sign is 0.012. For $x = 0.90$, the above ratios are 0.030 and 0.013 respectively. The maximum change that would arise in any of the computed discharges from taking any of the observed ratings instead of the adopted one would be 3 per cent. of the total discharge.

The next step in the reduction was to correct the soundings in the note-books for errors in the lead-line. The first determination of the lead-line corrections recorded in the notes was made October 11, prior to which date the corrections to be applied are uncertain. Subsequent to that date the lead-line corrections were well determined and generally were kept quite small by retagging of the line. A large portion of the time no correction at all was necessary.

The notes were then copied on the computation sheets and also the gauge reading, width, and direction and force of wind. The distances of the end soundings from the water's edge were computed and copied on the sheet at the beginning and end of the series of soundings. The areas included between the end soundings and the shores were computed as right-angle triangles. The soundings on the high water section, prior to October 14 were taken 150 feet apart, between October 14 and January 14, 75 feet apart, but all other soundings with very few exceptions were taken 50 feet apart.

The area between an end sounding and the shore would therefore be quite small usually, and, in fact, never equaled 1,700 square feet. The area between successive soundings was computed as if the section of the bed between the soundings was a right line. Where soundings were 50 feet apart areas could be written in by inspection After all the areas between soundings had been computed they were summed, and, with the end areas, gave the total water area of the section. This computation was then checked by computing the water area directly from the sum of the soundings.

If we let

$$[D] = \text{the sum of the soundings,}$$
$$D_1 \text{ and } D_2 = \text{the end soundings,}$$
$$r \text{ and } r_2 = \text{distances of end soundings from shore}$$

and

$$w = \text{distance between soundings,}$$

then,

$$\text{water area} = w\,([D] - \tfrac{1}{2}(D_1 + D_2)) + \tfrac{1}{2}(r_1 D_1 + r_2 D_2)$$

The areas between the middle points of the divisions into which the section was divided by the velocity stations were then summed and called partial areas. The sum of the areas between the shore and the middle point of the full division next the shore gave the partial area belonging to the velocity station next the shore. The sum of the partial areas gave the total area and formed a check on the computation of the partial areas.

The counting of the registrations of the meter had been done in the field and the results were adopted in the office computation. Until October 24 the length of time of an observation for velocity varied from 90 to 240 seconds, but subsequent to that date the time was uniformly 150 seconds. The computation of the velocities from the given times and registrations was performed by means of tables prepared for the purpose.

The measurements for velocity were uniformly taken at six-tenths the depth, and no coefficients have been applied to the observed velocities to reduce them to mean vertical velocities. The results of the observations made in 1882 showed that the mean velocity in a vertical was at 0.63 of the depth for the five stations occupied. (See Report M. R. C., 1884, p. 189.) It is quite probable therefore that velocities measured at 0.6 depth will not require any reductions. A large number of observations were made at this station for determining the form of the vertical curve of velocities, but have not yet been reduced.

The velocities on October 4, 6, and 9 were taken by means of rod floats, and are evidently largely in error. There is no note in regard to the lengths of floats used, and no coefficients of reduction have been applied to the observed velocities. The mean velocities determined by means of rod floats are about 75 per cent. of corresponding velocities determined by the meter, and discharges have the same ratio.*

The partial areas were multiplied by the corresponding velocities, giving the partial discharges. These multiplications were performed with a computing-machine, which very materially lessened the labor of what would otherwise have been a very tedious operation. The sum of the partial discharges gave the total discharge per second. A sample of the computation at this stage is here given.

* NOTE.—In a letter dated December 15, 1885, Assistant Weber states that he found an error in the base over which the floats were run, and that its length was 300 feet instead of 200 feet, as stated in the notes. This would increase the mean velocities and discharges measured by means of rod floats by 50 per cent. of their values as given in the tabulation.—L. L. W., Dec. 24, 1885.

Computation of discharge of Mississippi River at Helena, Arkansas.

Date, March 20, 1885. Gauge-reading, 33.11 feet. Width, 4,787 feet. Direction and force of wind, XII. Light.]

Station.	Soundings.	Area. Between soundings.	Area. Partial.	Registrations.	Time.	Velocity per second.	Partial discharge.
W. e. r. b. 61 ft.	*Feet.*	*Sq. ft.*	*Sq. ft.*	*No.*	*Sec.*	*Feet.*	*Cubic feet.*
1-2	18.0	549					
	26.6	1,115					
1	49.7	1,907	9,084	124.0	150	3.51	31,885
	57.1	2,670					
1-2	56.6	2,843					
	52.7	2,732					
2	70.0	3,068	12,415	154.0	150	4.30	53,385
	66.0	3,400					
1-2	62.6	3,215					
	61.6	3,105					
3	60.6	3,055	11,945	179.0	150	4.97	59,367
	57.6	2,955					
1-2	55.6	2,830					
	54.7	2,757					
4	53.2	2,698	10,637	175.0	150	4.86	51,696
	51.2	2,610					
1-2	51.7	2,572					
	51.2	2,573					
5	50.7	2,547	10,090	180.0	150	5.00	50,450
	49.7	2,510					
1-2	48.7	2,460					
	47.7	2,410					
6	46.8	2,363	9,570	184.0	150	5.10	48,807
	48.7	2,387					
1-2	47.7	2,410					
	47.3	2,375					
7	46.8	2,353	9,420	184.5	150	5.12	48,230
	47.3	2,352					
1-2	46.3	2,340					
	43.9	2,255					
8	43.4	2,183	8,598	182.0	150	5.05	43,420
	41.5	2,122					
1-2	40.0	2,038					
	39.0	1,975					
9	39.0	1,950	7,720	218.0	150	6.01	46,397
	38.1	1,927					
1-2	36.6	1,868					
	35.2	1,795					
10	35.2	1,760	6,982	192.0	150	5.32	37,144
	34.3	1,737					
1-2	33.3	1,690					
	31.9	1,630					
11	31.0	1,583	6,140	190.0	150	5.26	32,296
	28.5	1,487					
1-2	29.5	1,450					
	28.5	1,450					
12	28.0	1,413	5,570	185.0	150	5.13	28,574
	26.6	1,365					
1-2	27.1	1,342					
	26.1	1,330					
13	25.6	1,293	5,065	151.0	150	4.22	21,374
	23.7	1,232					
1-2	24.7	1,210					
	25.2	1,248					
14	25.2	1,260	4,940	154.0	150	4.30	21,242
	24.2	1,235					
1-2	23.7	1,197					
	24.7	1,210					
	24.7	1,235	4,890	132.9	150	3.72	18,191
	24.2	1,223					
1-2	24.7	1,222					
	24.7	1,235					
10	24.7	1,235	4,978	148.0	150	4.14	20,609
	25.2	1,248					
1-2	25.2	1,260					
	24.7	1,247					
17	24.7	1,235	4,940	138.0	150	3.88	19,167
	24.7	1,235					
1-2	24.2	1,223					
	23.7	1,197					
	24.2	1,198	4,815	136.0	150	3.82	18,393
	24.2	1,210					
1-2	24.2	1,210					
	24.7	1,222					

Computation of discharge of Mississippi River at Helena, Arkansas—Continued.

Station.	Soundings.	Area.		Registrations.	Time.	Velocity per second.	Partial discharge
		Between soundings.	Partial.				
W. e. r. b. 61 ft.	*Feet.*	*Sq. ft.*	*Sq. ft.*	*No.*	*Sec.*	*Feet.*	*Cubic feet.*
19	24.2	1,223	4,902	135.0	150	3.80	18,628
	24.7	1,222					
1-2	24.7	1,236					
	24.7	1,235					
20	24.7	1,235	5,045	124.0	150	3.50	17,658
	26.1	1,270					
1-2	26.1	1,305					
	26.1	1,305					
21	26.6	1,318	5,320	112.0	150	3.19	16,971
	27.1	1,342					
1-2	27.1	1,355					
	26.8	1,348					
22	26.6	1,335	5,343	107.0	150	3.05	16,296
	26.6	1,330					
1-2	26.0	1,330					
	26.1	1,317					
23	24.7	1,270	4,785	103.0	150	2.95	14,116
	22.2	1,173					
1-2	18.8	1,025					
	14.5	832					
24	7.0	538	1,461	50.0	150	1.54	2,250
W. e. l. b. 26 ft.		91					
		164,655	164,655	= Area.			736,546 = Disch'ge

The results of the computation at this stage were then copied into the tabulation accompanying this report. The gauge-reading for days on which areas were measured were taken from the observer's notes, and correspond to the mean time of the observations. The readings given for other days are the means of daily readings and correspond to 12 m. Until February 7 the gauge was read three times a day; subsequent to that date, twice daily. The gauge read was the standard gauge at Helena, the zero of which is 161.98 feet above Cairo datum plane. The rise or fall in twenty-four hours for any date is the difference between the mean-gauge readings for that day and the preceding one.

The computation of datum areas has been made in the following manner: For the high-water section datum was assumed to correspond to the reading 47.10 feet on the gauge. The datum width was taken as 4,851 feet, that being the measured width on January 29, 1885, when the gauge read 40.62 feet. The area included between datum and the water-surface of January 29 would therefore be 4,851 (47.10 — 40.62) = 31,434 square feet. The slope of the banks down to 16 feet on the gauge is quite uniform, and datum areas above 16 feet have been computed by the formula,

$$\text{Datum area} = 31434 + (40.62 - h)\left(\frac{4851 + w}{2}\right) + \text{water area},$$

where h = gauge reading and w = width.

At an elevation corresponding to 16 feet on the gauge the left bank becomes less abrupt, and datum areas below that stage have been computed by the formula,

$$\text{Datum area} = 31434 + (40.62 - 16)\left(\frac{4851 + 4610}{2}\right) + (16 - h)\left(\frac{4610 + w}{2}\right) + \text{water area}.$$

$$= 147887 + (16 - h)\left(\frac{4610 + w}{2}\right) + \text{water area}.$$

On November 20 450 square feet were added to the datum area for portion not sounded. From November 21 to 26, inclusive, soundings were not taken beyond station 12, about 3,600 feet from right bank. The area of the portion between station 12 and left bank and below the 16 foot stage has been computed from the soundings of November 19 and added to the observed areas, the formula then becoming,

$$\text{Datum area} = 158813 + (16 - h)\ 3260 + \text{water area}.$$

The datum area for December 9 was computed in the usual manner, except that soundings of December 4, corrected for change of stage, were used for 707 feet from left bank, which was too shoal to be sounded. The water area in this portion, as thus computed, was 3,384 square feet, which should really have been added to the observed area. There was no velocity in this portion of the section. The width should properly be 4,535 feet.

For the low-water section datum was assumed at the water-surface on January 7, 1885, the gauge reading 31.94 feet. The width on that day was 4,338 feet, which was taken as datum width. The slope of the banks at this section changes at elevations corresponding to readings of 20 and 14 feet on the gauge, the width on those stages being 4,163 and 3,770 feet, respectively. Datum areas have therefore been computed by the following formula:

Above 20 feet on gauge,

$$\text{Datum area} = (31.94 - h)\left(\frac{4338 + w}{2}\right) + \text{water area.}$$

Between 14 and 20 feet on gauge,

$$\text{Datum area} = 11.94\left(\frac{4338 + 4163}{2}\right) + (20 - h)\left(\frac{4163 + w}{2}\right) + \text{area.}$$

$$= 50745 + (20 - h)\left(\frac{4163 + w}{2}\right) + \text{water area.}$$

Below 14 feet on gauge,

$$\text{Datum area} = 50745 + (20 - 14)\left(\frac{4163 + 3770}{2}\right) + (14 - h)\left(\frac{3770 + w}{2}\right) + \text{area.}$$

$$= 74544 + (14 - h)\left(\frac{3770 + w}{2}\right) + \text{water area.}$$

Mean depth has been obtained by dividing the water area by the width, and mean datum depth has been obtained by dividing the datum area by the datum width. Maximum depth has been taken directly from the soundings. For the high-water section the changes in width are very large and are the cause of large changes in the mean depths when no change in section takes place. The range in the values of mean datum depth, subsequent to October 11, is 2.3 feet.

Scour or fill has been obtained by taking difference of datum areas. Scour is indicated by the positive sign.

Mean velocity has been obtained by dividing the discharge by the water area. Being dependent on both these quantities, it is affected to a greater or less degree by the errors of each and can hardly be regarded as an independent quantity. It may be affected by errors in the measurement or computation of the area or in the computation of the discharge, but the variations in its values in this series of observations come mainly from variations in the observed velocities themselves. The computation has been so arranged that one could readily compare the area, velocity, or discharge of any particular part of the section for one day with the same quantities of the same portion for days preceding or following. In a great many instances this has been done, and it has been observed that the change in velocity from one day to another where marked usually extended throughout the section. As it is hardly reasonable to suppose that the velocity of the stream actually changed as indicated by the mean velocities, the conclusion is unavoidable that the measured velocities are in error from some cause affecting all the velocities observed that day. One source of error lies in the fact that the meter measures motions which take place in a vertical direction, and that when the meter rises and falls under the action of the waves these motions are added to the velocity of the current. A striking illustration of the effect of this error is shown in the following table, where the parts making up the total discharges on three consecutive days are given. On March 12 the observer states that "high waves kept launch rocking up and down and from side to side" to such an extent as to make the work unreliable. It will be seen from the table that the velocities on that day are too large as compared with the preceding and following days. It will be also seen from the series of discharges that the discharge on this day is about 35,000 cubic feet, or about 6 per cent. too large. This error is without doubt caused by the meter measuring other motions than that of the current. Although this is an extreme case and rejected by the observer's notes, yet it is valuable as showing the amount of error that may arise in that way. It must not be taken as a measure of the precision of the work, neither must it be taken as condemning the use of the current meter.

In some instances, however, the change in mean velocity is due to a change in one or more measured velocities where the partial areas are large. Since, in determining the mean velocity and discharge, each observed velocity has weight according to its partial area, it would seem advisable to either measure the velocities where partial areas are large with greater precision than those where the partial areas are small, or else distribute the velocity station so as to give nearly equal partial areas.

Station.	Partial area.			Observed velocity.			Partial discharge.		
	Mar. 11.	Mar. 12.	Mar. 13.	Mar. 11.	Mar. 12.	Mar. 13.	Mar. 11.	Mar. 12.	Mar. 13.
1	6,316	6,674	7,131	3.11	3.53	3.48	19,643	23,559	24,816
2	10,300	10,887	11,138	4.73	4.57	4.52	48,719	49,753	50,344
3	9,775	10,375	10,710	4.89	4.86	4.69	47,800	50,423	50,229
4	8,638	9,175	9,492	4.70	5.08	4.62	40,599	46,609	43,853
5	7,852	8,525	8,765	4.92	5.34	5.02	38,681	45,524	44,000
6	7,513	7,950	8,440	5.05	5.18	5.53	37,941	41,181	46,673
7	7,187	7,675	8,043	4.97	5.24	4.98	35,719	40,217	40,051
8	6,575	7,075	7,500	4.94	5.40	4.48	32,481	38,205	33,600
9	5,500	6,225	6,605	4.86	5.46	5.14	26,730	33,989	33,950
10	4,850	5,350	5,692	4.33	4.97	5.00	21,001	26,590	28,460
11	4,118	4,463	4,873	4.33	5.05	4.76	17,809	22,538	23,195
12	3,437	3,962	4,237	4.04	4.65	3.81	13,885	18,423	16,143
13	2,950	3,525	3,850	3.90	4.34	4.21	11,505	15,299	16,209
14	2,913	3,325	3,793	3.50	4.25	3.62	10,196	14,131	13,731
15	2,937	3,363	3,742	3.56	3.77	3.69	10,456	12,679	13,808
16	3,023	3,475	3,838	3.56	3.80	3.21	10,762	13,205	12,320
17	3,100	3,412	3,800	3.35	3.80	3.32	10,385	12,966	12,616
18	3,025	3,300	3,825	3.40	3.21	3.09	10,285	10,593	11,819
19	3,050	3,400	3,637	3.03	3.13	3.17	9,242	10,642	11,529
20	3,162	3,525	3,913	2.89	3.32	3.30	9,138	11,703	12,913
21	3,350	3,825	4,150	3.13	3.48	3.08	10,486	13,311	12,782
22	3,438	3,938	4,187	2.84	2.92	3.09	9,764	11,499	12,938
23	3,254	3,795	4,331	2.31	2.20	2.66	7,517	8,349	11,520
	116,268	127,219	135,692	4.221	4.491	4.256	490,744	571,388	577,503

The direction of the wind is indicated by dividing the horizon into 12 parts and numbering the parts the same as the hours on a clock dial, XII being up-stream and indicating a down-stream wind. The force of the wind is not very well defined and is given in the tabulation as contained in the notes. In regard to the observed velocities it is quite probable that the direction of the wind is of more importance than the force, the up-stream (VI) winds being the ones that would produce the greatest waves.

Slope observations consisted in a number of readings of gauges on each bank approximately one-half mile above and below the sections, each section having its own set of slope gauges. The gauges were graduated to tenths of a foot and read by estimation to hundredths of a foot. Ten readings of each gauge were usually taken at three-minute intervals, 5 being taken simultaneously on the two upper gauges, then 10 on the two lower gauges, and, finally, 5 more on the upper gauges. All readings were reduced to the same datum and differences of reduced readings gave the fall of water-surface between the gauges. The distances of some of the gauges from the section have not been given in the notes. In these cases the distances have been assumed as one-half mile, on the supposition that the gauges were set in accordance with the instructions governing the work. The locations of the gauges as given, or assumed, are shown on the sketch of the locality. The fall divided by the distances between the gauges gave the sine of the inclination of the water-surface, this quantity being computed separately for each bank. The slope has been computed to seven places of decimals, but for want of space in the tabulation the first three places have been given at the head of the column.

The total fall from Mhoon's Landing, 30.5 miles above Helena, to Helena has been computed from the gauge-readings for the entire period of discharge observations at Helena. When the results are plotted as abscissas to gauge heights at Helena as ordinates, it is shown that the total fall between these places, for stages when the river is entirely within its banks, decreases as the stage at Helena increases. In other words, the fall from Mhoon's Landing to Helena and gauge heights at Helena appear to be decreasing functions of each other.

In the remarks accompanying the tabulation, three results have been marked as rejected from notes made by the observer. On a number of other dates the observer has noted high waves, and it would probably improve the series of observations to reject those results also; at least the mean velocity and discharge. In addition, all observations prior to October 11 should be rejected for several reasons. On October 11 the lead line was tested and found to have shrunk 3 feet in 50, and no data exists for determining what the error was on previous days. The discrepancies in the measured velocities, however, are very great prior to October 10, and are beyond any possible variations which could have taken place in the current itself, or that could arise from the different methods employed.

Accompanying this report is a plate on which are plotted the mean velocities, areas, and discharges of the high-water section as abscissas to gauge heights as ordinates,

the scale for each system of co-ordinates being given on the plate. The discharges of the low-water section are also plotted, but not the mean velocities and areas. Doubtful results are not plotted. The gauge-readings and datum areas of both sections have been plotted in chronological order, there having been added to the datum areas of the low-water section 80,000 square feet to make them approximately coincide with datum areas of the high-water section. The high-water section, as sounded on January 29, 1885, is also shown on the plate, the horizontal scale being 500 feet to the inch. The positions of the water-surfaces on the following dates are also shown: December 26, 1872, March 8, 1882, January 29, 1885, and March 4, 1885. The zero of the standard gauge coincides with the water-surface on December 26, 1872, and all gauge-readings in this series of observations refer to this zero. The water-surface on March 8, 1882, by one authority, is the highest known; but the regular gauge record gives the reading on March 9, 1882, as one-tenth foot higher. The dotted bottom line gives the section as sounded on March 4, 1885, and shows where the fill took place which occurred between January 29, 1885, and that date.

The gauge-readings, areas, datum areas, mean velocities, and discharges for both sections have also been plotted in chronological order on another plate for purposes of inspection and study. The scale is too large to admit of reproduction of the plate. When plotted in this manner the results, with few exceptions, follow each other in remarkable agreement, and clearly show the high grade and precision of the work done at this station.

In making the reductions nearly all the gentlemen employed in the computing division have at various times taken part. On account of the large reduction in force and of making this work secondary to other work, the completion of it has been long delayed. Throughout the entire work the greatest care has been taken to eliminate from the results all errors of computation. Wherever it was possible to obtain independent checks on the results they were applied, and where no checks could be obtained the work was gone over a second time. The computing machine has been largely used in the work, and has given good satisfaction.

Very respectfully, your obedient servant,

L. L. WHEELER,
In charge Computing Division.

Capt. THOMAS TURTLE,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

Discharge observations at Helena, Ark.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Right bank.	Left bank.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1884.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet.	Feet.	Sq. ft.	Feet.	Cubic ft.					
Oct. 1	10.20															
2	11.84	+1.64														
3	14.41	+2.24	81,196	236,397	17.7	48.7	54.0	4,590								
4	16.25	+1.97	93,090	239,721	20.2	49.4	57.0	4,604	+3,324	2.762	257,085	Calm			R. F.	
5	17.79	+1.74														
6	19.00	+1.26	107,649	241,605	23.2	49.8	60.0	4,634	+1,884	2.775	298,725	VI, light			R. F.	
7	19.94	+0.89														
8	20.21	+0.27	114,418	242,738	24.6	50.0	62.0	4,644	+1,133	3.697	423,011	VII, strong			Meter.	
9	20.00	—0.26	112,026	241,343	24.1	49.8	62.0	4,644	—1,395	2.773	310,614	XII, mod			R. F.	
10	19.50	—0.44	108,973	240,579	23.5	49.6	64.5	4,635	— 764	3.636	396,177	Calm			Meter.	
11	19.00	—0.51	102,952	236,800	22.2	48.8	61.0	4,628	—3,779	3.771	388,198	X, gentle			Meter.	
12	18.49	—0.51														
13	17.98	—0.46	97,080	235,750	21.0	48.6	59.0	4,624	—1,050	3.781	367,018	I, gentle			Meter.	
14	17.80	—0.37	97,920	237,361	21.2	48.9	61.4	4,616	+1,611	3.806	372,711	I, mod			Meter.	
15	17.50	—0.15	98,491	239,352	21.4	49.3	59.1	4,613	+1,991	3.699	364,290	I, gentle			Meter.	
16	17.62	+0.16	98,834	238,604	21.3	49.2	59.6	4,614	— 748	3.607	354,725	V, light			Meter.	
17	18.03	+0.31	100,104	238,547	21.6	49.2	59.5	4,623	— 57	3.924	392,804	I, gentle			Meter.	Reject.
18	18.30	+0.30	97,934	235,120	21.2	48.5	58.6	4,625	—3,427	3.638	356,274	II, light			Meter.	
19	18.41	+0.13														
20	18.45	+0.04	100,256	236,731	21.7	48.8	59.6	4,625	+1,611	3.729	373,818	IV, light			Meter.	
21	18.37	—0.10	99,994	236,848	21.6	48.8	59.5	4,626	+ 117	3.688	368,768	IV, light			Meter.	
22	18.24	—0.19	99,308	236,778	21.5	48.8	60.0	4,624	- 70	3.733	370,713	XII, mod			Meter.	
23	17.80	—0.43	97,876	236,886	21.1	48.8	58.5	4,621	+ 108	3.552	345,865	I, strong			Meter.	High waves.
24	17.30	—0.43														
25	16.90	—0.40	93,771	237,448	20.0	48.9	59.4	4,613	+ 562	3.814	357,629	II, light			Meter.	
26	16.54	—0.36														
27	16.28	—0.26	89,649	236,211	19.4	48.7	59.2	4,609	—1,237	3.725	333,961	XII, light			Meter.	
28	16.04	—0.25	88,247	235,944	19.2	48.6	59.0	4,607	— 267	3.854	340,108	XII, light			Meter.	
29	16.10	+0.06	87,189	234,553	18.9	48.4	58.9	4,606	—1,391	3.842	334,941	XII, light			Meter.	
30	16.23	+0.15	88,443	235,245	19.2	48.5	59.4	4,608	+ 692	3.770	333,438	XII, light			Meter.	
31	16.35	+0.11	87,821	234,052	19.0	48.2	59.4	4,610	—1,193	3.854	338,482	I, light			Meter.	
Nov. 1	16.34	—0.01	88,933	235,211	19.3	48.5	57.4	4,610	+1,159	3.740	332,002	V, light	.000 .0750	.000 .0728		
2	16.17	—0.17														
3	15.98	—0.20	87,128	235,107	18.9	48.5	57.9	4,609	— 104	3.707	328,212	V, light	.0828	.0729		
4	15.80	—0.17	86,253	235,062	18.7	48.5	58.0	4,607	- 45	3.810	329,422	XI, mod				

	5	15.56	−0.22	85,907	235,950	18.6	48.6	57.0	4,[illegible]	+[illegible]	3.[illegible]	[illegible]	[illegible]				
	6	15.15	−0.44	84,571	230,871	18.4	48.7	57.5	4,597	+421	3.830	328,878	XII, light				
	7	14.78	−0.39	82,794	236,295	18.0	48.7	56.8	4,594	−76	3.714	307,545	VI, light				
	8	14.20	−0.56	79,735	235,900	17.4	48.6	56.5	4,588	−393	3.704	296,330	VI, light				
	9	13.65	−0.54														
	10	13.14	−0.55	75,495	236,509	16.5	48.8	55.5	4,569	+609	3.750	288,109	VI, light				
	11	12.68	−0.47	75,155	238,490	16.5	49.2	57.0	4,557	+1,981	3.758	282,080	V, light				
	12	12.12	−0.52	72,241	237,906	15.9	49.0	53.0	4,555	−584	3.694	266,844	XII, light				
	13	11.75	−0.40	68,335	235,671	15.0	48.6	54.0	4,543	−2,235	3.736	255,318	XII, light				
	14	11.30	−0.44	66,890	236,284	14.7	48.7	52.5	4,541	+613	3.720	248,861	XII, light	.0595	.0729		
	15	11.00	−0.30	64,176	234,928	14.1	48.4	52.0	4,536	−1,356	3.686	236,537	V, light				
	16	10.61	−0.36														
	17	10.27	−0.35	61,257	235,324	13.5	48.5	58.8	4,528	+396	3.745	229,433	V, light				
	18	9.99	−0.27	60,816	235,639	13.3	48.6	53.0	4,521	+315	3.717	224,220	X, light				
	19	9.86	−0.13	58,414	234,330	12.9	48.3	53.2	4,519	−1,309	3.755	219,318	XII, light	(?).0551	(?).0549		
	20	9.69	−0.17	56,968	234,098	12.6	48.3	53.5	4,516	−232	3.603	205,276	IV, light				Reject discharge.
	21	9.59	−0.08	54,746	234,456	16.8	49.3	52.5	3,260	+358	3.800	208,034	V, light				Bar cuts off width.
	22	9.53	−0.09	54,309	234,214	16.7	48.3	52.0	3,260	−242	3.894	211,500	IV, strong				High waves and winds.
	23	9.56	+0.04														
	24	9.39	−0.16	54,088	234,450	16.6	48.3	52.0	3,260	+236	3.815	200,338	VI, light				
	25	9.34	−0.08	54,528	235,053	16.7	48.5	53.0	3,259	+603	3.859	210,411	VI, gentle				High waves.
	26	9.10	−0.23	53,448	234,755	17.2	48.4	52.5	3,110	−298	3.757	200,805	IV, light				
	27	8.90	−0.19	66,492	159,712	18.7	36.8	25.0	3,554		2.949	196,077	V, gentle				Low-water section.
	28	8.88	−0.03	65,468	158,761	18.4	36.6	25.0	3,555	−951	3.171	207,601	X, gentle				
	29	9.08	+0.22	65,544	158,110	18.4	36.4	25.0	3,556	−651	3.120	204,516	V, light				
	30	9.75	+0.65														
Dec.	1	10.48	+0.74	70,828	158,361	19.6	36.5	25.1	3,611	+251	3.078	217,991	IV, light	.000	.000		
	2	10.85	+0.37	71,753	157,965	19.7	36.4	26.5	3,638	−396	3.090	221,683	II, light	.0671	.0909		
	3	10.95	+0.10	71,534	157,875	19.7	36.3	26.0	3,638	−590	3.139	224,584	V, light				
	4	10.85	−0.10	71,525	157,727	19.7	36.4	26.0	3,632	+352	3.063	219,111	V, light				
	4	10.83		63,676	235,400	14.1	48.5	53.0	4,535	+645	3.825	244,331	V, strong				High-water section; high waves.
	5	10.64	−0.21	70,539	157,495	19.5	36.3	26.0	3,618	−232	3.074	216,827	V, light				Low-water section.
	6	10.30	−0.38	69,521	157,714	19.3	36.4	26.0	3,608	+219	3.258	226,476	V, mod				High waves.
	7	9.72	−0.54														
	8	8.97	−0.75	64,655	157,659	18.1	36.3	25.0	3,571	−55	2.909	188,103	I, light				
	9	8.37	−0.63	63,078	158,240	17.7	36.5	24.0	3,558	+581	2.847	179,607	I, light				
	9	8.30		50,250	236,725	15.8	48.8	51.0	3,190	+1,325	3.592	180,494	XII, light				High-water section.
	10	7.86	−0.48	61,355	158,845	17.8	36.5	23.0	3,547	+105	2.824	173,191	V, light				Low-water section.
	11	7.50	−0.37	59,911	158,147	17.0	36.5	23.0	3,521	−198	2.832	169,656	Calm				
	12	7.25	−0.23	58,963	158,117	16.8	36.4	23.0	3,520	−30	2.869	169,158	XI, light				
	13	7.17	−0.08	58,701	158,134	16.7	36.5	22.0	3,517	+17	2.875	168,754	XI, light	.0682			
	14	7.78	+0.60														
	15	8.52	+0.90	63,467	158,112	17.8	36.4	23.5	3,567	−22	3.038	192,794	IX, light				
	16	9.80	+1.21	67,742	157,759	18.8	36.4	25.0	3,598	−353	3.159	213,969	V, gentle	.0822	.0920		High waves.
	17	10.89	+1.08	71,940	158,003	19.8	36.4	27.0	3,638	+244	3.147	226,402	XI, light				
	18	12.11	+1.13	76,482	158,074	20.7	36.4	27.5	3,688	+71	3.245	248,203	XI, gentle				
	19	13.25	+1.15	80,506	157,864	21.6	36.4	28.5	3,735	−210	3.274	263,560	XII, gentle				
	20	14.14	+0.94	83,507	157,504	22.1	36.3	29.5	3,774	−360	3.277	273,619	IV, light				
	21	14.89	+0.67														

Discharge observations at Helena, Ark.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Right bank.	Left bank.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1884.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cubic ft.*					
Dec. 22	15.22	+0.37	83,346	158,149	23.2	36.5	31.0	3,811	+ 645	3.351	296,071	XI, gentle	....	....	....	
23	15.24	0.00	87,272	156,986	22.9	36.2	31.0	3,808	—1,163	3.348	292,210	XII, light	....	....	....	
24	14.84	—0.41	86,306	157,608	22.7	36.3	30.6	3,806	+ 622	....	....	....	....	....	....	
25	13.96	—0.86	....	....	....	....	....	....	....	....	....	....	....	....	....	
26	12.93	—0.98	....	....	....	....	....	....	....	....	....	....	....	....	....	
27	12.13	—0.85	....	....	....	....	....	....	....	....	....	....	....	....	....	
28	12.15	+0.02	....	....	....	....	....	....	....	....	....	....	....	....	....	
29	12.95	+0.80	....	....	....	....	....	....	....	....	....	....	....	....	....	
30	15.11	+1.93	86,994	157,221	22.9	36.2	29.9	3,806	— 387	3.493	303,898	IV, light	....	....	....	
31	17.56	+2.89	97,850	158,471	24.9	36.5	32.5	3,931	+1,250	3.717	363,707	XI, light	.0637	.1015	....	
1885.																
Jan. 1	20.68	+2.97	110,220	158,131	26.4	36.5	35.5	4,173	— 340	3.884	428,052	XI, gentle	.000	.000	....	
2	24.04	+3.15	124,968	158,780	29.6	36.6	40.0	4,221	+ 649	4.111	513,756	II, light	....	....	....	
3	26.90	+3.02	137,010	158,657	32.2	36.6	43.5	4,253	— 123	4.418	605,356	II, light	....	....	....	
4	29.15	+2.24	....	....	....	....	....	....	....	....	....	....	....	....	....	
5	30.59	+1.44	....	....	....	....	....	....	....	....	....	....	....	....	....	
6	31.55	+0.96	....	....	....	....	....	....	....	....	....	....	....	....	....	
7	31.94	+0.41	155,039	155,039	35.7	35.7	47.0	4,338	—3,618	4.598	712,894	V, light	....	....	....	Chute discharge=3,530 cubic feet not included.
7	32.00	....	163,585	236,498	34.3	48.8	76.0	4,774	— 227	4.217	689,860	V, light	....	....	....	High-water section.
8	32.20	+0.30	162,704	234,680	34.0	48.4	76.0	4,779	—1,818	4.387	713,732	VI, mod	....	....	....	High waves.
9	32.49	+0.25	164,613	235,201	34.4	48.5	75.2	4,781	+ 521	4.297	707,260	VII, light	....	....	....	
10	32.78	+0.28	166,774	235,973	34.9	48.6	75.0	4,783	+ 772	4.244	707,810	III, light	....	....	....	
11	33.11	+0.32	....	....	....	....	....	....	....	....	....	....	....	....	....	
12	33.65	+0.59	170,707	235,771	35.6	48.6	76.5	4,800	— 202	4.415	753,708	XI, light	....	....	....	
13	34.40	+0.64	174,877	236,360	36.4	48.7	77.6	4,805	+ 589	4.468	781,352	XI, light	....	....	....	
14	35.02	+0.68	177,319	235,807	36.8	48.6	78.6	4,820	— 553	4.467	792,019	IV, light	....	....	....	
15	35.82	+0.80	....	....	....	....	....	....	....	....	....	....	....	....	....	
16	36.48	+0.66	....	....	....	....	....	....	....	....	....	....	....	.0938	....	
17	36.88	+0.40	185,988	235,490	38.5	48.5	79.0	4,829	— 317	4.443	826,367	XI, light	....	....	....	
18	37.25	+0.37	....	....	....	....	....	....	....	....	....	....	....	....	....	
19	37.62	+0.37	188,788	234,715	39.1	48.4	79.5	4,831	— 775	4.503	850,195	I, light	....	....	....	
20	37.97	+0.36	190,491	233,727	39.2	48.2	81.5	4,831	— 988	4.605	872,500	I, light	....	....	....	
21	38.32	+0.34	192,291	234,836	39.8	48.4	82.2	4,831	+1,109	4.714	906,530	XI, light	....	....	....	

22	38.69	+0.37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
23	39.13	+0.44											.0000	.0000		
24	39.48	+0.35														
25	39.82	+0.34														
26	40.10	+0.27	201,871	235,322	41.6	48.5	83.5	4,841	− 443	4.818	970,175	IX, light				
27	40.36	+0.27	204,693	237,388	42.2	48.9	83.5	4,850	+2,066	4.822	987,063	VII, mod				High waves.
28	40.48	+0.12	205,619	237,732	42.4	49.0	83.5	4,851	+ 344	4.964	1,020,743	XII, light				
29	40.62	+0.14	206,060	237,494	42.5	49.0	80.5	4,851	− 238	4.907	1,013,129	II, light	.0902	.1023		
30	40.62	−0.01														
31	40.49	−0.12														
Feb. 1	39.74	−0.75											.000	.000		
2	38.54	−1.22	193,687	235,205	40.0	48.5	80.0	4,844	−2,289	4.538	878,985	V, light				
3	36.80	−1.68	185,169	235,107	38.3	48.5	79.0	4,836	− 98	4.405	815,765	VII, light	.0806	.1051		
4	34.86	−1.99	176,032	235,310	36.6	48.5	78.0	4,816	+ 203	4.125	726,081	IX, light				
5	32.74	−2.12	163,629	233,005	34.3	48.0	78.0	4,778	−2,305	4.201	687,408	IX, gentle				
6	30.94	−1.78	156,238	234,223	32.8	48.3	74.0	4,766	+1,218	3.979	621,748	VI, light	.0858	(?).0388		
7	29.15	−1.63	148,849	235,282	31.4	48.5	72.0	4,739	+1,059	4.200	625,236	VI, gentle				High waves.
8	27.92	−1.40														
9	27.02	−0.90	136,682	233,124	29.0	48.1	68.0	4,709	−2,158	4.073	556,640	X, strong				High waves.
10	26.62	−0.40	134,802	233,142	28.6	48.1	69.0	4,707	+ 18	4.045	545,224	X, light				
11	26.54	−0.08	134,907	233,629	28.7	48.2	70.0	4,707	+ 487	3.997	530,293	IV, light	(?).1111	.0814		
12	26.66	+0.12	136,973	235,121	29.1	48.5	70.0	4,707	+1,492	4.033	552,392	IV, light				
13	26.86	+0.22	136,981	234,174	29.1	48.3	70.0	4,708	− 947	4.037	533,044	I, light				
14	27.01	+0.14	135,659	232,176	28.8	47.9	69.0	4,714	−1,998	3.984	540,506	VI, light	.0852	.0890		
15	27.36	+0.34														
16	27.98	+0.62														
17	28.65	+0.67														
18	29.34	+0.69														
19	29.53	+0.18	146,355	230,988	30.9	47.6	72.0	4,743	−1,188	4.110	601,475	II, light	.0833	.0909		
20	29.38	−0.16	144,977	230,329	30.6	47.5	71.0	4,743	− 659	4.120	598,605	II, light				
21	28.48	−0.78														
22	27.47	−1.11														
23	26.04	−1.43														
24	24.52	−1.52														
25	22.70	−1.82														
26	21.18	−1.52														
27	19.44	−1.74														
28	18.35	−1.07	90,885	227,790	19.7	47.0	58.0	4,621	−2,539	3.975	361,275	VI, gentle		.0758		Rough.
Mar. 1	17.46	−0.91											.000	.000		
2	16.83	−0.65	84,368	228,305	18.3	47.1	57.0	4,607	+ 515	3.954	333,598	II, light	.0962	.0701		
3	16.50	−0.31	83,076	228,573	18.0	47.1	56.0	4,606	+ 268	3.949	328,063	VI, light				
4	16.52	+0.02	83,816	229,219	18.2	47.3	54.0	4,606	+ 646	4.004	335,578	I, gentle				
5	16.83	+0.32	84,942	228,879	18.4	47.2	55.0	4,612	− 340	3.966	336,915	I, light	.1011	.0724		
6	17.42	+0.64	87,861	229,008	19.0	47.2	54.0	4,616	+ 129	4.043	355,231	X, light				
7	18.27	+0.89	91,505	228,833	19.8	47.2	57.0	4,625	− 175	4.046	370,255	XI, gentle				
8	19.32	+0.94														
9	20.38	+1.17	101,205	228,738	21.8	47.2	57.0	4,645	− 95	4.184	423,432	VI, gentle	(?).0623	(?).1519		
10	21.86	+1.53	107,613	228,213	23.1	47.0	59.0	4,655	− 525	4.249	457,225	VI, light		.0758		
11	23.72	+1.76	116,268	228,146	24.9	47.0	60.5	4,670	− 67	4.221	490,744	V, light				
12	25.81	+2.02	127,219	229,341	27.1	47.3	63.0	4,696	+1,195	4.491	571,888	VI, strong				High waves. Reject.
13	27.51	+1.80	135,692	229,753	28.7	47.4	64.4	4,725	+ 412	4.256	577,503	XI, light				

Discharge observations at Helena, Ark.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Right bank.	Left bank.		
			Water.	Below datum.	Mean.	Mean. datum.	Maximum.									
1885.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cubic ft.*					
Mar. 14	28.70	+1.16	142,354	230,956	30.0	47.6	64.7	4,741	+1,203	4.431	630,758	VII, light	.0975	.1402	......	
15	29.45	+0.69													......	
16	29.98	+0.57	148,884	231,379	31.4	47.7	67.3	4,747	+ 423	4.327	644,278	V, light	.0919	.0947	......	
17	30.72	+0.76	153,733	232,727	32.3	48.0	67.6	4,757	+1,348	4.338	666,833	XII, light			......	
18	31.57	+0.88	157,328	232,283	33.0	47.9	67.6	4,767	− 444	4.426	696,322	VIII, light			......	
19	32.37	+0.76	161,120	232,261	33.7	47.9	69.5	4,775	− 22	4.452	717,361	X, gentle	.0814	.0871	......	
20	33.11	+0.20	164,655	232,280	34.4	47.9	70.0	4,787	+ 19	4.473	736,516	XII, light			......	
21	33.57	+0.95													......	
22	33.68	+0.11													......	
23	33.57	−0.11	167,211	232,668	34.8	48.0	72.0	4,802	+ 388	4.411	737,616	II, light	.0833	.0909	......	
24	33.45	−0.11	166,964	232,999	34.8	48.0	71.0	4,801	+ 331	4.338	724,222	VI, light			......	
25	33.23	−0.23	164,995	232,078	34.4	47.8	70.0	4,798	− 921	4.220	696,316	II, light			......	
26	32.86	−0.35	163,380	232,210	34.1	47.9	70.5	4,787	+ 132	4.247	693,922	VI, light	.0786	.0875	......	
27	32.34	−0.50	161,700	232,977	33.9	48.0	69.0	4,773	+ 767	4.210	680,798	VI, light			......	
28	31.53	−0.74	158,781	233,929	33.3	48.2	70.0	4,767	+ 952	4.173	662,562	XII, gentle			......	
29	30.81	−0.93													......	
30	29.55	−1.16	147,818	232,374	31.2	47.9	69.0	4,741	−1,555	4.151	613,794	VI, gentle			......	
31	28.31	−1.27	142,020	232,419	30.0	47.9	66.0	4,729	+ 45	3.941	559,656	V, light	.0882	.0932	......	
Apr. 1	26.01	−1.37	134,607	231,602	28.6	47.7	65.0	4,713	− 817	3.979	535,563	V, light	.000	.000	......	
2	25.65	−1.29	129,594	232,465	27.6	47.9	64.0	4,691	+ 863	3.983	516,110	VI, gentle			......	
3	24.68	−0.96	124,857	232,245	26.7	47.9	62.6	4,679	− 220	4.039	504,251	XI, gentle			......	
4	23.88	−0.76	119,685	230,801	25.6	47.6	63.4	4,669	−1,444	3.856	461,514	XII, light			......	
5	23.31	−0.50													......	
6	22.98	−0.33													......	
7	23.16	+0.06	115,485	230,505	24.7	47.5	63.3	4,669	− 296	3.919	452,560	VII, light			......	
8	23.60	+0.56													......	
9	24.70	+1.16	124,013	230,354	26.5	47.5	65.2	4,684	− 151	4.164	516,169	V, light	.0941	.0994	......	
10	26.25	+1.46	130,842	230,907	27.8	47.6	65.4	4,700	+ 553	4.140	541,611	II, light			......	

(c) ARKANSAS CITY, ARKANSAS.

SAINT LOUIS, *April* 13, 1887.

CAPTAIN: I have the honor to submit the following report upon the final reduction discharge observations made on the Mississippi River at Arkansas City, Ark., ›tween September 29, 1884, and April 9, 1885.

The party at this station was under the direction of Assistant Engineer G. W. 'ood. Mr. E. E. Wall acted as recorder throughout the season. A steam engineer ›d two boatmen completed the party.

Observations were made upon a section about one-half mile below Arkansas City. he ends of the section were marked by range signals and along the left bank a series signals at right angles to the section were set to locate positions on the section by eans of a sextant set at the constant angle 14° 02′. (For further explanation of this ethod of location, see report of Mississippi River Commission for 1883, p. 181.)

The instruments in use at this station consisted of Price meters B, No. 7 and No. 13, Morse register, a break-circuit clock, electric batteries, transit, level, sextant, sound›g lines, etc. (The instruments and manner of using them were similar to those at eiena, which have already been described in my report upon the reduction of work ; that station.)

Meter No. 7 was used from the commencement of operations until January 24, 1885, 'hen it was lost. Four series of observations were made by Mr. Wood for deter›ining the coefficients of this meter, but the results of all of them have been rejected a account of the small range in velocities and the large errors of observation. A ›ries of observations for the same purpose were made by Capt. Smith S. Leach, Jan›ary 8, 1885, in running water, the results of which have been adopted for reducing ll observations made with this meter. The following table contains the results of he several series of observations for determining the coefficients of this meter:

Date.	No. of observations.	a	b	e_0	e_a	e_b
›ctober 21, 1884*	14	+3.864	−0.041	±0.085	±0.118	±0.087
'ovember 3, 1884*	21	+3.572	+0.478	±0.202	±0.153	±0.153
'ovember 12, 1884*	21	+3.737	+0.376	±0.171	±0.120	±0.115
)ecember 4, 1884*	15	+4.084	−0.050	±0.129	±0.103	±0.097
'anuary 8, 1885†	20	+3.770	+0.520	±0.099	±0.022	....

* Taken in still water. † Taken in running water.

Meter B was used from January 31 to February 12, inclusive. No observations were made for determining its coefficients, but three series of observations had been made by Capt. Smith S. Leach and Assistant L. C. Jones, early in January, and the means of the results obtained from these three series were adopted for reducing observations made with this meter. These same values were used in reducing observations made with this meter at Red River Landing, and the results of the several series of observations are given in my report upon the reduction of work at that station. The adopted values for this meter are,

$$y + 1.783\,x + 0.239$$

Meter No. 13 was used from February 13 to the end of the season. Three series of observations for determining the coefficients of this meter were made, one by Mr. Bowen, at Carrollton, and two by Mr. Wood. The results are given in the following table:

Date.	No. of observations.	a	b	e_0	e_a	e_b
February 4, 1885*	6	+3.882	+0.318	±0.043	±0.018	±0.029
February 18, 1885†	26	+3.912	+0.347	±0.115	±0.023	....
March 20, 1885†	22	+3.942	+0.219	±0.136	±0.031	....

* Taken in still water. † Taken in running water.

NOTE.—In the rating taken by Mr. Bowen, February 4, 1885, an apparatus was used by means of which the observations were both made and recorded automatically. This rating is a fine example of observations well made and also properly arranged to give great weight to the results. The ratings of February 18 and March 20, and also that of Meter No. 7, taken January 8, are good examples of ratings made in running water, and are a proof of the value of this method of rating current meters.

The mean values of a and b were adopted for reducing observations made with th meter, making the equation for this meter,

$$y = + 3.912\,x + 0.295$$

The preceding values for the several meters have been used throughout the enti series of observations. The counting of registrations of the meter had been done i the field and the results were adopted in the office reduction. The launch was n anchored while measuring velocities at this station. Prior to October 12 observatio for velocity were made with the meter at not more than 12 feet beneath the surfac No coefficients have been applied to these velocities to reduce them to six-tent depth velocities. Subsequent to October 12 all observations for velocity were ma at six-tenths the depth from the surface. Velocities were measured at points on t cross-section approximately 160 feet apart. The computation of velocities was ma by means of tables prepared for the purpose, except those measured by Meter B, whe the velocities were computed directly by means of the equation.

Prior to December 1 the note is quite frequently made that while the velocity wa being measured the launch drifted laterally by amounts varying from 10 to 100 fe If we let—

l = lateral movement in feet,

t = time in seconds,

y = measured velocity, and

c = correction to be applied to y on account of lateral movement, then,

$$c = y - \frac{\sqrt{t^2 y^2 - l^2}}{t} = \frac{l^2}{2\,t^2\,y} + \frac{l^4}{6\,t^4\,y^3} + \text{etc.}$$

As $t^2\,y$ largely exceeds l^2 this series converges rapidly, and the first term will usual give the correction with the desired accuracy. At Arkansas City t is usually 120 se onds, and the formula becomes

$$= \frac{1}{28800}\,\frac{l^2}{y} + \frac{1}{1244160000}\,\frac{l^4}{y^3} + \text{etc.}$$

The maximum value of c that would be obtained by using this formula would b per cent. of the measured velocity, but commonly the value of c would be less th 1 per cent. of the measured velocity. The effect of this correction on the mean vel ity for any date would probably not exceed 1 per cent. The correction has not be applied.

The next step in the reduction was to correct the soundings for errors of lead lin The lead-line corrections were usually determined once each week, but on some occ sions large changes took place in the lead line with no means of determining ju when the changes occurred. It was assumed, however, that the line changed propo tionally to the time, and soundings on intermediate dates were corrected on th assumption. It is impossible to estimate what errors may have been introduced this manner of correcting the soundings.

The cross-sections were then plotted on a horizontal scale of 1 inch = 400 feet a a vertical scale of 1 inch = 10 feet. Depths were then scaled off at intervals of feet and used in computing the partial areas, which were computed and checked the manner described in my report upon the reduction of work at Helena.

Velocities were also plotted on the same sheets with the cross-sections with t same horizontal scale and a vertical scale of 1 inch = 1 foot per second. The tran verse curves of velocity were then drawn and velocities scaled from the curves points 160 feet apart, to be used with the partial areas in computing the partial di charges. The plotting of cross-sections and velocity curves, the scaling of dept and velocities, the multiplication of partial areas by velocities, and the summati of partial discharges have all been checked by a second computer going over th same work.

The clock used at this station had a large rate during the latter part of the season, and it became necessary to correct the results on this account. These corrections were applied directly to the total discharges instead of to each individual velocity.

The results of the computation were then copied into the tabulation accompanying this report. The gauge readings for days on which areas were measured were taken from the observers' notes and correspond to the mean time of observations. Prior to October 18, however, the observer did not read the gauge, and the readings for dates prior to October 18 have been taken from the regular gauge record at this station. The readings given for other days are the means of daily readings and correspond to 12 m. The gauge read was the standard gauge at Arkansas City, the zero of which is 116.35 feet above Cairo Datum Plane. Mr. Wood, however, states that the gauge is inclined to such an extent as to materially change this value. The results of his

leveling substantiates his statement. The rise or fall in twenty-four hours for any date is the difference between the mean gauge readings for that date and the preceding one.

The computation of datum areas has been made in the following manner: Datum was assumed to correspond to the gauge reading 41.73 feet, observed January 31, 1885. Datum width was taken as 3,380 feet. The slope of the bank was assumed to be uniform below 10 feet on the gauge, between 10 and 20 feet, between 20 and 30 feet, and between 30 and 41.73 feet. The width at 10 feet was taken as 3,220 feet, at 20 feet as 3,300 feet, and at 30 feet as 3,350 feet. Datum areas have then been computed by the following formulæ, in which h represents gauge reading and w observed width.

Between 30 and 41.73 feet on gauge—

$$\text{Datum area} = (41.73 - h)\frac{3380 + w}{2} + \text{water area}.$$

Between 20 and 30 feet on gauge—

$$\text{Datum area} = (41.73 - 30)\frac{3380 + 3350}{2} + (30 - h)\frac{3350 + w}{2} + \text{w. area}.$$

$$= 39471 + (30 - h)\frac{3350 + w}{2} + \text{water area}.$$

Between 10 and 20 feet on gauge—

$$\text{Dat. ar.} = 39471 + (30 - 20)\frac{3350 + 3300}{2} + (20 - h)\frac{3300 + w}{2} + \text{w. area}.$$

$$= 72721 + (20 - h)\frac{3300 + w}{2} + \text{water area}.$$

Below 10 feet on gauge—

$$\text{Dat. ar.} = 72721 + (20 - 10)\frac{3300 + 3220}{2} + (10 - h)\frac{3220 + w}{2} + \text{w. ar.}$$

$$= 105321 + (10 - h)\frac{3220 + w}{2} + \text{water area}.$$

Mean depth has been obtained by dividing the observed area by the observed width. Mean datum depth has been obtained by dividing the datum area by the datum width. Maximum depth has been taken directly from the corrected soundings. Scour or fill has been obtained by taking differences of datum areas. Scour has been indicated by the positive sign. Mean velocity has been obtained by dividing the discharge by the area.

The direction of the wind is given in the notes with reference to the banks and the current. In the tabulation it has been given with reference to the points of the compass. The force of the wind is not well defined and is given in the tabulation as contained in the notes.

A number of slope observations were made by reading gauges on each bank approximately one half mile above and below the section, but the results have been rejected on account of large discrepancies.

Accompanying this report is a plate on which are plotted the mean velocities, areas and discharges as abscissas to gauge heights as ordinates. The gauge-readings and datum areas have been plotted on the plate in chronological order. The section as sounded January 31, 1885, is also shown on the plate. The gauge-readings, areas, datum areas, mean velocities, and discharges have also been plotted in chronological order on another plate for purposes of inspection and study. The scale is too large to admit of reproduction of the plate.

Very respectfully, your obedient servant,

L. L. Wheeler,
In charge Computing Division.

Capt. Smith S. Leach,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

Discharge observations at Arkansas City, Ark.

Date.	Gauge.		Dimensions of cross section of discharge.									
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
1884.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet*	*Sq. ft.*	*Feet.*	*Cu. ft.*	
Oct. 1	7.80	....	......	......	......	......	......	......	......	......	......	
2	8.70	+0.90	......	......	......	......	......	......	......	......	......	
3	10.40	+1.70	......	......	......	......	......	......	......	......	......	
4	12.50	+2.10	......	......	......	......	......	......	......	......	......	
5	14.80	+2.30	......	......	......	......	......	......	......	......	......	
6*	16.60	+1.80	139,391	223,301	42.5	66.1	80.0	3,282	......	3.263	454,778	
7*	18.05	+1.45	145,106	224,247	44.2	66.3	82.0	3,285	+ 916	3.344	485,275	
8	19.25	+1.20	153,954	229,149	46.7	67.8	82.5	3,298	+4,902	3.472	534,514	
9*	20.00	+0.75	149,885	222,606	45.4	65.9	84.5	3,302	−6,543	3.594	538,721	
10*	20.60	+0.60	159,929	230,664	48.4	68.2	84.0	3,302	+8,058	3.449	551,566	
11	21.00	+0.40	......	......	......	......	......	......	......	......	......	
12	20.65	−0.35	......	......	......	......	......	......	......	......	......	
13	20.15	−0.50	153,144	225,370	46.4	66.7	82.0	3,299	−5,294	3.149	482,228	
14	19.50	−0.65	150,069	224,469	45.5	66.4	82.0	3,299	− 910	2.977	446,851	W.
15	18.85	−0.65	145,259	221,773	44.1	65.6	81.5	3,295	−2,088	2.915	428,418	Calm.
16	18.40	−0.45	143,698	221,695	43.6	65.6	81.0	3,295	− 77	2.826	406,063	Do.
17	18.15	−0.25	143,583	222,404	43.6	65.8	80.0	3,295	+ 709	2.972	426,741	
18	18.10	−0.05	144,477	223,403	43.8	66.1	81.0	3,295	+1,059	2.863	413,667	Do.
19	18.25	+0.15	......	......	......	......	......	......	......	......	......	
20	18.47	+0.05	144,501	222,268	43.8	65.8	81.0	3,296	−1,195	2.806	405,416	NE., light.
21	18.50	0.00	144,034	221,702	43.7	65.6	81.5	3,296	− 566	2.907	418,640	SE., light.
22	18.42	0.00	143,372	221,304	43.5	65.5	80.5	3,295	− 398	2.890	414,295	
23	18.20	−0.20	141,906	220,556	43.1	65.3	79.5	3,295	− 748	2.943	417,592	W., strong.
24	17.95	−0.25	139,656	219,137	42.4	64.8	81.0	3,295	−1,419	2.823	394,222	E., light.
25	17.55	−0.35	138,468	219,257	42.1	64.9	81.0	3,286	+ 120	2.710	375,263	
26	17.10	−0.40	......	......	......	......	......	......	......	......	......	
27	16.75	−0.45	135,446	218,861	41.3	64.8	77.0	3,281	− 396	2.773	375,631	Calm.
28	16.43	−0.40	133,524	217,990	40.7	64.5	77.0	3,279	− 871	2.676	357,325	W., strong.
29	16.20	−0.15	131,501	216,718	40.1	64.1	77.0	3,277	−1,272	2.691	353,917	Calm.
30	16.05	−0.05	130,136	215,847	39.7	63.9	77.0	3,277	− 871	2.707	352,295	Do.
31	16.30	+0.20	132,444	217,334	40.4	64.3	78.0	3,278	+1,487	2.660	352,219	Do.
Nov. 1	16.50	+0.40	134,536	218,775	41.0	64.7	78.0	3,282	+1,441	2.723	366,394	Do.
2	16.60	+0.05	......	......	......	......	......	......	......	......	......	
3	16.40	−0.15	131,074	215,643	39.9	63.8	77.0	3,282	−3,132	2.688	352,363	Do.
4†	16.25	−0.20	130,370	215,430	39.7	63.7	77.0	3,281	− 213	2.750	358,517	NW., strong.
5	16.10	−0.10	130,578	216,126	39.8	63.9	78.0	3,278	+ 696	2.774	362,230	NW., light.
6	16.00	−0.15	130,875	216,750	39.9	64.1	77.0	3,277	+ 624	2.741	358,775	W.
7	15.70	−0.25	129,375	216,232	39.5	64.0	77.0	3,275	− 518	2.669	345,291	Calm.
8	15.20	−0.45	126,492	214,931	38.7	63.6	75.5	3,270	−1,251	2.673	338,146	Do.
9	14.65	−0.65	......	......	......	......	......	......	......	......	......	
10	14.00	−0.70	121,535	213,951	37.2	63.3	76.0	3,265	−1,030	2.575	312,907	Do.
11	13.35	−0.50	120,405	214,938	36.9	63.6	74.0	3,260	+ 987	2.486	299,275	Do.
12	12.75	−0.65	118,694	215,177	36.5	63.7	73.0	3,255	+ 239	2.496	296,235	Do.
13	12.25	−0.65	115,843	213,949	35.6	63.3	72.5	3,251	−1,228	2.460	284,955	Do.
14	11.70	−0.50	113,466	213,361	34.9	63.1	72.0	3,248	− 588	2.370	268,895	Do.
15	11.18	−0.45	112,829	214,413	34.8	63.4	73.0	3,245	+1,052	2.377	268,251	Do.
16	10.70	−0.50	......	......	......	......	......	......	......	......	......	
17	10.25	−0.40	108,334	212,859	33.6	63.0	70.0	3,224	−1,554	2.349	254,452	Do.
18	9.85	−0.40	107,053	212,851	33.8	63.0	68.5	3,165	− 8	2.270	243,034	NW., light.
19	9.50	−0.30	105,972	212,881	33.6	63.0	69.0	3,154	+ 30	2.472	261,932	Do.
20	9.25	−0.40	104,704	212,462	33.6	62.9	69.0	3,119	− 419	2.298	240,774	Calm.
21	9.05	−0.05	103,376	211,708	33.1	62.6	68.5	3,119	− 754	2.419	250,047	SE., light.
22	8.93	−0.15	103,016	212,628	33.3	62.9	68.3	3,119	+ 920	2.435	253,004	E., strong.
23	9.00	0.00	......	......	......	......	......	......	......	......	......	
24	8.90	−0.05	103,042	211,849	33.0	62.7	68.5	3,119	− 770	2.521	259,781	Calm.
25	8.83	−0.15	103,046	212,075	33.0	62.7	69.0	3,119	+ 226	2.357	242,869	SW., light.
26	8.67	−0.10	102,466	212,002	32.9	62.7	68.5	3,118	− 73	2.399	245,850	Do.
27	8.58	−0.10	101,707	211,526	32.7	62.6	68.2	3,115	− 476	2.342	238,191	Do.
28	8.50	−0.10	......	......	......	......	......	......	......	......	......	
29	8.66	+0.10	101,842	211,407	32.7	62.5	68.0	3,115	− 119	2.362	240,522	
30	9.10	+0.50	......	......	......	......	......	......	......	......	......	
Dec. 1	9.77	+0.60	105,412	211,466	33.4	62.6	69.0	3,154	+ 59	2.454	258,684	S., light.
2	10.66	+0.80	107,216	210,427	32.2	62.3	69.5	3,229	−1,039	2.637	282,728	Calm.
3	11.38	+0.70	110,268	211,198	34.0	62.5	69.5	3,245	+ 771	2.600	287,696	Calm.
4	11.89	+0.70	111,773	211,046	34.4	62.4	70.0	3,248	− 152	2.617	292,500	S., strong.
5	12.00	+0.05	111,208	210,129	34.2	62.2	70.5	3,250	− 917	2.581	287,037	S. E., strong.
6*	11.60	−0.35	110,719	210,942	34.1	62.4	69.5	3,216	+ 813	2.894	320,386	S., very strong.
7	10.85	−0.75	......	......	......	......	......	......	......	......	......	

* Reject.

† Water rough.

Discharge observations at Arkansas City, Ark.—Continued.

Date.	Gauge.		Dimensions of cross section of discharge.									
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
1884.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet	Feet.	Sq. ft.	Feet.	Cu. ft.	
Dec. 8	10.82	−0.60	106,816	211,137	33.1	62.5	69.5	3,229	+ 195	2.434	259,904	Calm.
9	9.56	−0.70	103,542	210,297	32.8	62.2	69.0	3,154	− 810	2.431	251,606	Calm.
10	8.80	−0.76	100,404	209,528	32.2	62.0	68.0	3,119	− 769	2.465	247,521	Calm.
11*	8.22	−0.60	98,200	209,249	31.6	61.9	67.0	3,115	− 279	2.626	258,131	S., strong.
12	7.82	−0.40	96,818	209,073	31.1	61.8	66.4	3,114	− 176	2.418	234,212	W., strong.
13	7.42	−0.35	94,694	208,202	30.4	61.6	66.4	3,111	− 871	2.338	221,390	N.E., light.
14	7.50	0.00	......	......	......	......	......	......	......	......	......	
15	8.81	+1.35	99,689	208,684	32.0	61.7	67.7	3,115	+ 482	2.438	242,907	Calm.
16	10.94	+2.15	107,009	209,306	33.1	61.9	69.2	3,229	+ 622	2.676	286,283	S.E., light.
17	12.76	+2.10	112,401	208,851	34.5	61.8	71.7	3,255	− 455	2.853	320,685	N.W., strong.
18*	15.01	+1.80	116,9.9	206,087	35.8	61.0	74.7	3,268	−2,764	2.881	337,310	N.W., strong.
19	16.57	+1.65	124,801	208,810	38.0	61.8	76.2	3,282	+2,723	2.925	365,023	N., light.
20	17.58	+1.00	127,399	208,089	38.8	61.6	78.6	3,286	− 721	3.050	389,672	S.S., light.
21	18.10	+0.55	......	......	......	......	......	......	......	......	......	
22	18.41	+0.25	131,855	209,820	40.0	62.1	77.6	3,296	+1,731	3.144	414,584	N., strong.
23	18.41	+0.10	128,318	206,283	38.9	61.0	78.1	3,296	−3,537	3.060	392,721	N., light.
24†	18.14	−0.25	128,980	207,834	39.1	61.5	78.4	3,295	+1,551	3.076	396,752	N., strong.
25	17.85	−0.35	......	......	......	......	......	......	......	......	......	
26	16.80	−0.80	123,436	206,690	37.6	61.2	75.8	3,281	−1,145	2.957	365,000	Calm.
27	15.85	−1.2	......	......	......	......	......	......	......	......	......	
28	15.3	−0.50	......	......	......	......	......	......	......	......	......	
29	14.98	−0.45	117,421	206,633	35.9	61.1	73.5	3,270	− 56	2.805	330,965	E., strong.
30	16.8	+1.60	121,488	204,574	37.0	60.5	75.0	3,281	−2,059	3.093	375,724	N., strong.
31	20.28	+3.50	131,365	203,150	39.8	60.1	77.2	3,299	−1,424	3.486	457,871	N.W., strong.
1885.												
Jan. 1†	23.33	+3.35	142,430	204,104	43.1	60.4	77.7	3,305	+ 954	3.913	557,296	N.W., very strong.
2	26.12	+2.80	154,537	206,901	46.6	61.2	82.6	3,313	+2,797	4.123	637,141	N., light.
3	28.71	+2.55	162,507	206,285	48.8	61.0	87.0	3,328	− 616	4.428	719,521	Calm.
4	31.10	+2.40	......	......	......	......	......	......	......	......	......	
5	32.90	+1.80	......	......	......	......	......	......	......	......	......	
6	34.55	+1.65	......	......	......	......	......	......	......	......	......	
7	35.55	+0.9	184,498	205,322	54.9	60.7	91.9	3,359	− 963	4.837	892,383	S., light.
8	36.20	+0.80	......	......	......	......	......	......	......	......	......	
9	36.85	+0.55	194,569	211,039	57.7	62.4	96.5	3,370	+5,717	4.982	969,430	N., light.
10	37.30	+0.50	201,606	216,559	59.8	64.1	102.2	3,370	+5,520	4.803	960,502	E., light.
11	37.60	+0.25	......	......	......	......	......	......	......	......	......	
12	38.10	+0.35	207,12	219,374	61.4	64.9	105.2	3,371	+2,815	4.907	1,016,372	N., light.
13	38.40	+0.45	202,055	212,990	59.9	63.0	103.4	3,371	−6,384	4.798	969,431	N., strong.
14	39.05	+0.60	202,334	211,448	60.0	62.6	101.6	3,371	−1,542	5.167	1,045,446	N.E., light.
15	39.80	+0.80	......	......	......	......	......	......	......	......	......	
16†	41.28	+0.55	207,854	212,748	61.7	62.9	102.6	3,371	+1,300	5.374	1,117,022	N.W., strong.
17	40.61	+0.25	207,350	211,131	61.5	62.5	102.9	3,372	−1,617	5.152	1,068,270	W., strong.
18	40.95	+0.35	......	......	......	......	......	......	......	......	......	
19	41.04	+0.10	207,404	200,734	61.5	62.1	102.8	3,374	−1,397	5.307	1,100,708	N., light.
20	41.20	+0.16	209,210	211,000	62.6	62.4	103.0	3,375	+1,260	5.114	1,069,814	N.W., light.
21	41.30	+0.10	......	......	......	......	......	......	......	......	......	
22	41.35	0.10	207,877	209,161	61.6	61.9	103.0	3,376	−1,839	5.158	1,072,260	N., light.
23	41.48	+0.10	211,451	212,296	62.6	62.8	102.8	3,377	+3,135	5.165	1,092,097	Calm.
24	41.50	+0.10	......	......	......	......	......	......	......	......	......	
25	41.50	0.00	......	......	......	......	......	......	......	......	......	
26	41.50	0.00	......	......	......	......	......	......	......	......	......	
27	41.60	+0.10	......	......	......	......	......	......	......	......	......	
28	41.70	+0.10	......	......	......	......	......	......	......	......	......	
29	41.70	0.00	......	......	......	......	......	......	......	......	......	
30	41.69	0.00	218,608	218,748	61.7	61.7	102.9	3,380	+6,452	......	......	
31	41.73	0.04	217,778	217,778	64.4	64.4	103.9	3,380	− 970	4.886	1,064,462	W., light.
Feb. 1	41.70	0.00	......	......	......	......	......	......	......	......	......	
2	41.61	−0.05	216,234	216,640	64.0	61.1	103.9	3,380	−1,138	4.979	1,076,725	S., light.
3	41.34	−0.35	216,288	217,606	64.0	61.4	103.9	3,380	+ 966	4.853	1,049,734	S., light.
4	40.79	−0.45	217,134	220,305	64.4	65.2	103.9	3,374	+2,702	4.727	1,026,300	S., strong.
5	39.10	−1.10	215,970	222,147	64.1	65.7	103.6	3,371	+1,839	4.541	980,803	W., very strong
6	38.72	−1.00	212,234	222,393	63.0	65.8	102.7	3,371	+ 246	4.382	929,601	S., light.
7	37.46	−1.25	205,316	210,720	60.9	65.0	102.6	3,371	−2,664	4.229	868,374	S., strong.
8	36.30	−1.20	......	......	......	......	......	......	......	......	......	
9	35.14	−1.15	193,968	216,189	57.7	61.0	90.4	3,361	−3,540	4.058	787,120	W., strong.
10	34.15	−1.00	......	......	......	......	......	......	......	......	......	

* Reject. † High waves.

Discharge observations at Arkansas City, Ark.—Continued.

Date.	Gauge.		Dimensions of cross section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1885.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu ft.*	
Feb. 11	33. 59	—0. 45	188, 421	215, 837	56. 2	63. 9	97. 1	3, 356	— 352	3. 944	743, 225	S., light.
12	33. 19	—0. 50	184, 158	212, 912	54. 9	63. 0	96. 8	3, 354	—2, 925	3. 966	730, 365	N.
13	32. 93	—0. 25	184, 790	214, 420	55. 1	63. 4	95. 6	3, 354	+1, 508	4. 074	752, 836	N., light.
14	32. 70	—0. 20	184, 080	214, 484	54. 9	63. 5	95. 5	3, 354	+ 64	4. 171	767, 829	Calm.
15	32. 55	—0. 20										
16	32. 25	—0. 20	179, 871	211, 785	53. 6	62. 7	95. 5	3, 353	—2, 699	4. 078	733, 525	W., light.
17	32. 18	—0. 15	181, 758	213, 908	54. 2	63. 3	95. 5	3, 353	+2, 123	4. 178	759, 442	S., light.
18	32. 25	0. 00	179, 674	211, 588	53. 6	62. 6	95. 6	3, 353	—2, 320	4. 090	734, 787	W., strong.
19	32. 30	+0. 10										
20	32. 20	—0. 10	180, 956	213, 039	54. 0	63. 0	95. 7	3, 353	+1, 451	4. 188	757, 822	N., strong.
21	31. 97	—0. 20	180, 207	213, 064	53. 7	63. 0	94. 7	3, 353	+ 25	4. 028	725, 963	N. E., light.
22	31. 35	—0. 65										
23	30. 52	—0. 75	175, 006	212, 694	52. 3	62. 9	93. 3	3, 344	— 370	3. 822	668, 902	NE., strong.
24	29. 64	—0. 85	168, 823	209, 499	50. 5	62. 0	91. 2	3, 342	—3, 195	3. 707	625, 866	NW., light.
25	28. 45	—1. 10	162, 084	206, 738	48. 6	61. 2	90. 0	3, 338	—2, 761			Calm.
26	27. 05	—1. 60										
27	25. 39	—1. 30	152, 179	207, 050	45. 7	61. 3	85. 0	3, 331	+ 312	3. 354	510, 424	S., light.
28	24. 01	—1. 60	146, 272	205, 744	43. 9	60. 9	83. 7	3, 328	—1, 306	3. 311	484, 270	E., light.
Mar. 1	22. 80	—1. 35										
2	22. 09	—0. 70	144, 366	210, 146	43. 7	62. 2	83. 7	3, 302	+4, 402	3. 255	469, 891	Calm.
3	21. 81	—0. 25	144, 518	211, 225	43. 8	62. 5	83. 2	3, 301	+1, 079	3. 166	457, 584	Calm.
4	21. 77	—0. 05	145, 777	212, 617	44. 2	62. 9	82. 7	3, 301	+1, 392	3. 266	476, 135	NE., strong.
5	21. 85	+0. 05	144, 162	210, 736	43. 7	62. 4	84. 5	3, 301	—1, 881	3. 182	458, 682	N., strong.
6	22. 15	+0. 25	145, 437	211, 013	44. 1	62. 4	82. 6	3, 301	+ 277	3. 237	470, 825	SW., light.
7	22. 62	+0. 50	146, 945	210, 962	44. 5	62. 4	85. 5	3, 302	— 51	3. 340	490, 803	N., strong.
8	23. 15	+0. 55										
9	23. 83	+0. 75	152, 241	212, 298	45. 8	62. 8	85. 2	3, 323	+1, 336	3. 309	503, 789	SE., light.
10	24. 53	+0. 75	154, 370	212, 111	46. 4	62. 8	87. 0	3, 330	— 187	3. 460	534, 116	SW., strong.
11	25. 48	+0. 80	155, 650	210, 222	46. 7	62. 2	87. 3	3, 332	—1, 889	3. 486	542, 651	SW., light.
12	26. 70	+1. 30	158, 835	209, 340	47. 6	61. 9	88. 1	3, 337	— 882	3. 576	567, 990	S., light.
13	28. 08	+1. 30	164, 755	210, 648	49. 3	62. 3	89. 2	3, 340	+1, 308	3. 827	630, 445	W., light.
14	29. 26	+1. 20	168, 436	210, 385	50. 3	62. 2	91. 0	3, 346	— 263	3. 747	631, 086	S., light.
15	30. 20	+0. 95										
16	30. 87	+0. 65	174, 438	210, 998	52. 0	62. 4	92. 1	3, 353	+ 613	4. 002	698, 138	S., light.
17	31. 37	+0. 50	174, 567	209, 454	52. 0	62. 0	93. 3	3, 355	—1, 544	4. 107	716, 933	N., strong.
18	32. 02	+0. 65	180, 981	213, 699	53. 9	63. 2	96. 4	3, 359	+4, 245	4. 100	741, 980	NW., light.
19	32. 71	+0. 70	178, 824	209, 230	53. 2	61. 9	92. 0	3, 362	—4, 469	4. 287	766, 661	W., strong.
20	33. 41	+0. 80	180, 488	208, 543	53. 6	61. 7	94. 8	3, 364	— 687	4. 316	779, 062	N., light.
21	34. 01	+0. 60	184, 859	210, 902	54. 9	62. 4	96. 5	3, 367	+2, 359	4. 186	773, 810	
22	34. 40	+0. 30										
23	34. 75	+0. 25	187, 655	211, 209	55. 7	62. 5	97. 6	3, 369	+ 307	4. 202	788, 488	N., light.
24	34. 83	+0. 20	192, 356	215, 643	57. 1	63. 8	97. 2	3, 370	+4, 437	4. 165	801, 188	NE., light.
25	34. 86	+0. 15	188, 825	212, 011	56. 0	62. 7	96. 8	3, 370	—3, 632	4. 193	791, 786	NE., light.
26	34. 75	—0. 15	189, 316	212, 873	56. 2	63. 0	98. 9	3, 370	+ 862	4. 234	801, 535	Calm.
27	34. 55	—0. 25	188, 810	213, 039	56. 0	63. 0	96. 7	3, 369	+ 166	4. 181	789, 380	S., light.
28	34. 28	—0. 35	188, 165	213, 290	55. 9	63. 1	96. 5	3, 365	+ 251	4. 352	818, 810	NW., strong.
29	33. 90	—0. 35										
30	33. 30	—0. 60	185, 640	214, 058	55. 2	63. 3	95. 5	3, 362	+ 768	4. 002	742, 849	S., light.
31	32. 60	—0. 65	181, 149	211, 908	53. 9	62. 7	94. 5	3, 358	—2, 150	3. 946	714, 826	Calm.
April 1	31. 75	—0. 70	178, 475	212, 078	53. 2	62. 7	94. 0	3, 354	+ 170	3. 851	687, 259	SE., light.
2	30. 80	—1. 05	173, 935	210, 714	51. 9	62. 3	94. 0	3, 350	—1, 364	3. 844	668, 617	S., strong.
3	29. 90	—1. 05	167, 984	207, 790	50. 1	61. 5	89. 5	3, 351	—2, 924	3. 896	654, 455	NW., strong.
4	28. 86	—0. 90	165, 699	208, 986	49. 5	61. 8	91. 0	3, 345	+1, 196	3. 729	617, 823	N., light.
5	28. 00	—0. 95										
6	27. 34	—0. 70	159, 934	208, 303	47. 9	61. 6	86. 0	3, 340	— 683	3. 512	561, 739	S., light.
7	26. 92	—0. 40	157, 807	207, 579	47. 3	61. 4	86. 0	3, 339	— 724	3. 553	560, 652	SE., light.
8	26. 77	—0. 10	157, 628	207, 908	47. 2	61. 5	87. 0	3, 343	+ 329	3. 544	558, 663	E., strong.
9	27. 06	+0. 20	157, 554	206, 864	47. 1	61. 2	85. 0	3, 343	—1, 044	3. 601	567, 279	SE., light.

(*d*) WARRENTON, MISS.

SAINT LOUIS, *December* 23, 1885.

CAPTAIN: I have the honor to submit the following report upon the final reduction of discharge observations on the Mississippi River at Warrenton, Miss., between October 1, 1884, and April 6, 1885.

The party at this station was under the charge of Assistant Engineer J. W. Dorst

throughout the time of observations. Mr. F. R. Hathaway acted as a recorder to November 30 and Mr. I. O. Walker performed the same duties to the end of the season.

Observations at this station were made upon two parallel sections 200 feet apart and about one half mile below the landing at Warrenton. The lower section was used up to and including March 4, 1885, the upper one being used subsequent to that date. The ends of the sections were marked by range signals, and along the left bank a series of signals in a line at right angles to the section were set to locate positions on the section by means of a sextant set at the constant angle 14° 02′. A pocket sextant was used in locating positions on the section and was too small an instrument to give accurate locations with so small an angle. (For further explanation of this method of location see Report M. R. C. for 1883, p. 181.)

The instruments in use at this station consisted of Price meter No. 8, a Morse register, a break-circuit clock, electric batteries, transit, level, sextant, sounding leads and lines, etc. (The instruments and manner of using them were similar to those at Helena, which have already been described in my report on the reduction of work at that station.)

The coefficients to be used in reducing registrations of the meter to velocity in feet per second depend upon two series of observations. The first of these was made by Captain Smith S. Leach, January 11, 1885, the meter being moved alternately up and down stream through running water over a given distance and the time and number of registrations being observed.

Let z = velocity of the water supposed to be constant,
c = velocity of the meter through space,
x = number of registrations per second,
y = velocity of the meter through the water, and
a and b constants to be determined.

The observations have been reduced on the assumption that the relations of the quantities are expressed by the equations:

$y = c - z = ax + b$ (when meter moves with the current.
$y = c + z = ax + b$ (when meter moves against the current.)

The eleven observations gave the following results:

$$a = +3.802$$
$$b = +0.335$$
$$z = +1.386$$
$$e_0 = \pm 0.056 = \text{mean error of an observation.}$$

The maximum residual error in the equations was 0.179.

The second series of observations was made by Assistant Dorst, March 18, 1885, in still water, and gave the following results:

$$a = +3.883$$
$$b = +0.447$$
$$e_0 = \pm 0.272 = \text{mean error of an observation.}$$

In combining these results, those of the first series were arbitrarily given five times the weight of those of the second series, and the resulting equation between the variables became:

$$y = 3.815\,x + 0.354.$$

These values have been used in reducing all the observations at this station.

The soundings were corrected in the note-books for errors of the lead line. The lead line corrections during the latter part of the season were very large, being about 12 feet in 70. As the soundings were not taken at regular intervals, the cross-sections were plotted on a horizontal scale of 1 inch = 200 feet, and on a vertical scale of 1 inch = 10 feet, and the depths at intervals of 100 feet scaled off from these cross-sections. Up to December 15, 1884, velocities were not measured at regular intervals across the section. The observed velocities for this period were plotted on the cross-sections with a vertical scale of 1 inch = 1 foot per second, and the transverse curve of velocities drawn. These velocities were then scaled off at intervals of 200 feet, and, with the scaled depths, were copied on the computation sheets, together with the width, gauge reading, and direction and force of wind. Subsequent to January 2, 1885, velocities were observed at intervals of 200 feet, and were copied directly on the computation sheets. They have also been plotted on the cross-section sheets. The distance of the water's edge on each bank from the base was given in the notes, by means of which the distances of the end soundings from the shore were computed. The areas between soundings, partial areas, and total areas were then computed in the same manner as already described for Helena.

The counting of the registrations of the meter had been done in the field and the results were adopted in the office computations. The length of time of an observation

for velocity varied, but the exact times are not stated in the notes. The computation of the velocities from the registrations per second was performed by means of tables prepared for the purpose. The measurements for velocity were taken at six-tenths the depth, and no coefficients have been applied to the observed velocities to reduce them to mean vertical velocities. The partial areas were multiplied by the corresponding velocities to obtain partial discharges.

The results of the computation were then copied into the tabulation accompanying this report. The gauge-readings for days on which areas were measured were taken from the observer's notes and correspond to the mean time of the measurements for area. The readings given for other days are the means of the readings taken on each day when more than one were taken. The gauge was not read at regular hours, and hence the mean does not correspond to any particular hour. When but one reading was taken that has been given. The gauge read was established by Assistant Dorst on the left bank at the section. Its zero is stated in the notes to have been 65 feet above Cairo Datum Plane, but a comparison with gauge-readings at Vicksburg and Saint Joseph, and also with the readings of slope gauges on the opposite side of the river, shows that its zero was about 64 feet above Cairo Datum Plane. The quantities given in the column headed "Rise or fall in the preceding twenty-four hours," are the differences of gauge-readings, and do not correspond to the change in twenty-four hours.

The computation of datum areas has been made in the following manner: For the first section, datum was assumed to correspond to the gauge-reading of 41.46 feet observed February 2, 1885, that being the maximum gauge-reading during the period of observations. The width on that date was 3,812 feet. The observed area on that date was 180,371 feet. The slope of the bank was assumed to be uniform below the stage of 15 feet, between 15 and 25 feet, between 25 and 35 feet, and between 35 and 41.46 feet, the widths being taken as follows:

At the stage of 15 feet, width = 2,510 feet.
At the stage of 25 feet, width = 2,982 feet.
At the stage of 35 feet, width = 3,386 feet.

The areas between these stages, used in computing datum areas of lower stages, are as follows:

Between 15 and 25 feet, area = 27,460 square feet.
Between 25 and 35 feet, area = 31,840 square feet.
Between 35 and 41.46 feet, area = 23,250 square feet.

The datum areas for the first section have then been computed by the following formulæ, h being gauge reading, and w width:

$$\text{Above 35 feet, datum area} = (41.46-h)\left(\frac{3{,}812+w}{2}\right) + \text{water area.}$$

$$\text{Between 25 and 35 feet, datum area} = 23{,}250+(35-h)\left(\frac{3{,}386+w}{2}\right) + \text{water area.}$$

$$\text{Between 15 and 25 feet, datum area} = 55{,}090+(25-h)\left(\frac{2{,}982+w}{2}\right) + \text{water area.}$$

$$\text{Below 15 feet, datum area} = 82{,}550+(15-h)\left(\frac{2{,}510+w}{2}\right) + \text{water area.}$$

For the second section, datum has been assumed to correspond to the gauge reading 33.99 feet, that being the highest stage at which observations were made on that section. The width at that stage was 3,352 feet. The datum areas for this section have been computed by the formulæ:

$$\text{Datum area} = (33.99-h)\left(\frac{3{,}352+w}{2}\right) + \text{water area.}$$

Mean depth has been obtained by dividing the water area by the width, and mean datum depth has been obtained by dividing the datum area by the datum width. Maximum depths have been taken directly from the soundings.

Scour or fill has been obtained by taking differences of datum areas, scour being indicated by the positive sign.

Mean velocity has been obtained by dividing the discharge by the water area.

The direction of the wind is indicated by the point of the compass from which it comes, and the force is given in terms of its velocity in miles per hour.

Slope observations consisted of a number of readings of gauges on each bank at distances from the section varying from less than one-half mile to about one mile. Ten readings of each gauge were taken at three-minute intervals, five being taken simultaneously on the two upper gauges, then ten on the two lower gauges and, finally, five more on the upper gauges. It is stated that the gauges were all set to read from 65 feet above the Cairo Datum Plane, but as the resulting elevations of water-surface on the left bank are uniformly about 1 foot higher than on the right bank, it is evident that such could not have been the case. The gauges on the left bank are

without doubt about 64 feet above Cairo Datum Plane. The slope has been computed in terms of the sine of the inclination and is given in terms of the seventh place of decimals.

Accompanying this report is a plate on which are plotted the mean velocities, areas, and discharges of both sections as abscissas to gauge heights as ordinates, the scales for each system of co-ordinates being given on the plate. The gauge-readings and datum areas of both sections have been plotted in chronological order, there having been added to the datum areas of the second section 20,000 square feet to make them approximately coincide with datum areas of the first section. The first section, as sounded on February 2, 1885, is also shown on the plate.

The gauge-readings, areas, datum areas, mean velocities, and discharges for both sections have been plotted in chronological order on another plate for purposes of inspection and study. The scale is too large to admit of reproduction of the plate.

In making the reductions nearly all the gentlemen employed in the computing division have taken part. The greatest care has been taken to eliminate from the results all errors of computation.

Very respectfully, your obedient servant,

L. L. WHEELER,
In charge Computing Division.

Capt. THOMAS TURTLE,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

Discharge observations at Warrenton, Miss.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.	
			Area.		Depth.									
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.						Right bank.	Left bank.
1884.	Ft.	Ft.	Sq. ft.	Sq. ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft.	Ft.	Cu. ft.			
Oct. 1														
2														
3														
4														
5														
6	8.57													
7	9.27	+0.70												
8	12.67	+3.40	88,753	177,081	36.2	46.5	61.0	2,451		4.629	410,828	Calm		
9	14.17	+1.50												
10	14.57	+0.40												
11	15.87	+1.30												
12	16.67	+0.80												
13	16.87	+0.20												
14	16.87	0.00	98,913	176,631	38.3	46.3	63.0	2,581	— 470	4.654	460,512	N., ¾		
15	16.07	−0.80	97,519	177,327	38.2	46.5	64.2	2,555	+ 676	4.331	422,347	N., ½		
16	15.87	−0.20	96,924	177,286	38.0	46.5	64.9	2,553	— 41	4.202	407,262	Calm		
17	15.30	−0.57	94,994	176,740	37.8	46.4	63.8	2,513	— 546	4.529	430,199	N., ½		
18	14.92	−0.38												
19	14.67	−0.25												
20	14.63	−0.04												
21	14.74	+0.11												
22	14.87	+0.13	91,721	174,597	36.6	45.8	62.0	2,509	−2,143	4.019	368,626	N., 2		
23	14.78	−0.09												
24	14.67	−0.11												
25	14.52	−0.15	89,881	173,635	35.8	45.6	62.0	2,508	— 926	4.323	388,524	E., 2		
26	14.17	−0.35												
27	13.93	−0.24												
28	13.58	−0.35	88,870	174,950	36.2	45.9	60.2	2,454	+1,315	3.796	337,350	Calm		
29	13.20	−0.38												
30	12.80	−0.40	87,250	175,258	35.7	46.0	59.5	2,444	+ 308	3.839	334,961	N., ½		
31	12.64	−0.16												
Nov. 1	12.57	−0.07												
2	12.70	+0.13												
3	12.84	+0.14												
4	12.87	+0.03	84,972	172,798	34.8	45.3	50.8	2,444	−2,460	3.937	334,521			
5	12.74	−0.13												
6	12.63	−0.11	83,640	173,285	34.3	45.5	59.2	2,438	+ 587	4.032	337,211	NE., 2		

Discharge observations at Warrenton, Miss.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.	
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Left bank.	Right bank.
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1884.	Ft.	Ft.	Sq. ft.	Sq. ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft.	Ft.	Cu. ft.			
Nov. 7	12.51	—0.12												
8	12.32	—0.19	84,578	174,247	34.8	45.7	59.3	2,433	+ 862	3.974	336,139	Calm		
9	12.07	—0.25												
10	11.59	—0.48	82,622	173,561	34.3	45.5	58.9	2,410	— 686	3.789	313,047	Calm		
11	11.02	—0.57												
12	10.58	—0.44	81,422	174,744	34.4	45.9	58.4	2,364	+1,183			Calm		
13	9.70	—0.88	78,948	174,345	33.8	45.8	57.6	2,338	— 399			Calm		
14	9.14	—0.56	76,259	172,908	33.1	45.4	56.3	2,303	—1,437	3.601	274,623	NE., ½		
15	8.45	—0.69	75,858	174,115	33.2	45.7	55.8	2,287	+1,207	3.695	280,311	Calm		
16	8.05	—0.40												
17	7.27	—0.78	72,342	173,305	32.1	45.5	54.1	2,253	— 810	3.444	240,154	Calm		
18	6.84	—0.43												
19	6.33	—0.51	70,228	173,291	31.6	45.5	55.0	2,222	— 14	3.445	241,911	NW., ½		
20	5.83	—0.50												
21	5.49	—0.34												
22	5.11	—0.38	66,614	172,415	30.4	45.2	53.7	2,192	— 876	3.545	236,156	E., 2		
23	5.02	—0.09												
24	4.96	—0.06	67,015	173,069	30.9	45.4	53.8	2,172	+ 654	3.279	226,448	NE., ½		
25	4.83	—0.13												
26	4.74	—0.09												
27	4.61	—0.13	66,280	173,826	30.7	45.6	53.0	2,160	+ 757	3.550	235,274	W., ½		
28	4.56	—0.05												
29	4.45	—0.11	64,880	172,033	30.1	45.1	53.3	2,155	—1,793	3.345	217,045	S., ½	317	— 275
30	4.48	+0.03												
Dec. 1	4.60	+0.12	65,750	171,714	30.4	45.0	53.8	2,160	— 319	3.607	237,192	SW., ½		
2	5.00	+0.40												
3	5.57	+0.57	68,095	172,862	30.9	45.3	53.8	2,202	+1,148	3.252	221,440	SE., ½		
4	6.38	+0.81	69,606	172,551	31.3	45.3	54.8	2,221	— 311	3.547	246,917	S., 2		
5	7.30	+0.92												
6	7.79	+0.49	70,547	170,235	31.4	44.7	55.4	2,244	—2,316	3.046	257,229	S., 4		
7	7.75	—0.04												
8	7.53	—0.22												
9	6.94	—0.59	69,582	171,170	31.4	44.9	55.5	2,214	+ 935	3.428	238,538			
10	6.42	—0.52	67,985	170,724	31.0	44.8	55.3	2,196	— 446	3.650	248,177	S., ¼	822	— 550
11	5.62	—0.80												
12	5.05	—0.57	66,150	172,033	30.3	45.1	54.1	2,180	+1,309	3.389	224,197	NW., 4		
13	4.27	—0.78	64,605	172,317	29.6	45.2	52.6	2,180	+ 284	3.344	216,026	N., 1		
14	3.86	—0.41												
15	3.61	—0.25	63,405	172,653	29.1	45.3	52.3	2,177	+ 336	3.297	200,054	Calm	728	— 550
16	3.96	+0.35												
17	5.23	+1.27											—1,065	—1,567
18	6.96	+1.73												
19	9.27	+2.31												
20	11.26	+1.99												
21	12.50	+1.24												
22	13.84	+1.34												
23	14.48	+0.64												
24	14.77	+0.29												
25	14.92	+0.15												
26	14.76	—0.16												
27	14.23	—0.53												
28	13.70	—0.53												
29	13.98	+0.28												
30	14.29	+0.31												
31	14.77	+0.48												
1885.														
Jan. 1	16.55	+1.78												
2	19.58	+3.03	105,631	176,211	38.7	46.2	69.1	2,735	+3,558	5.016	529,870	NE., 3		
3	22.37	+2.79												
4	24.84	+2.47												
5	27.45	+2.61												
6	29.48	+2.03												
7	29.72	+0.24											747	523
8	30.96	+1.24	149,220	185,786	46.6	48.7	81.6	3,205	+9,575	5.941	886,498	SW., ½		
9	32.03	+1.07												
10	32.68	+0.65	151,236	182,228	46.0	47.8	84.2	3,288	—3,558	5.968	902,605	SW		
11	33.30	+0.62												
12	33.94	+0.64	154,039	180,858	46.0	47.4	85.1	3,348	—1,370	5.757	886,846	S., ½		
13	34.53	+0.59	154,928	179,770	45.7	47.2	85.4	3,368	—1,088	6.371	987,031	S., ½		
14	35.48	+0.95												

Discharge observations at Warrenton, Miss.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.	
			Area.		Depth.									
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.						Left bank.	Right bank.
1884.	Ft.	Ft.	Sq. ft.	Sq. ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft.	Ft.	Cu. ft.			
15	36.29	+0.81											— 653	793
16	37.07	+0.78												
17	37.86	+0.79												
18	38.49	+0.63	161,562	172,435	46.0	45.2	86.7	3,510	−7,335	6.237	*1,007,795	N., ½		
19	38.78	+0.29												
20	39.13	+0.35												
21	39.43	+0.30	170,608	178,158	47.0	46.7	90.4	3,626	+5,723	6.400	†1,091,871	N., ½		
22	39.94	+0.51	170,975	176,646	46.9	46.3	90.3	3,650	−1,512	6.729	1,150,556	N., 2		
23	40.27	+0.33	172,524	176,977	47.0	46.4	90.8	3,672	+ 331	6.381	‡1,100,885	Var., 1		
24	40.69	+0.42												
25	40.88	+0.19	175,447	177,624	47.5	46.6	90.7	3,696	+ 647	6.185	1,085,098	Var., 1		
26	41.08	+0.20												
27	41.14	+0.06											374	444
28	41.24	+0.10	175,788	176,630	45.8	46.3	90.6	3,840	− 994	5.861	1,030,240	N., ¾	358	476
29	41.31	+0.07	175,584	176,158	45.8	46.2	89.4	3,835	− 472	6.258	1,098,843	S., 1		
30	41.32	+0.01	175,765	176,300	45.8	46.2	89.6	3,836	+ 142	6.099	§1,071,912	Calm		
31	41.34	+0.02											259	523
Feb. 1	41.30	−0.04												
2	41.46	+0.16	180,371	180,371	47.3	47.3	90.6	3,812	+4,071	5.879	1,060,477	S., 1		
3	41.51	+0.05												
4	41.41	−0.10											333	603
5	41.26	−0.15	176,558	177,319	46.5	46.5	91.6	3,800	−3,052	6.092	1,075,608	W., 5		
6	40.99	−0.27												
7	40.35	−0.64	179,696	183,843	49.2	48.2	89.3	3,654	+6,524	5.870	1,054,848	S., 6		
8	40.12	−0.23												
9	39.33	−0.79	168,509	176,369	47.2	46.3	84.8	3,568	−7,474			W., 8		
10	38.05	−1.28												
11	37.28	−0.77												
12	36.75	−0.53	159,046	176,242	45.6	46.2	79.0	3,490	− 127			Calm	543	587
13	35.97	−0.78												
14	35.35	−0.62	153,352	175,342	45.3	46.0	79.4	3,386	− 900	5.046	773,851	Calm		
15	34.68	−0.67												
16	34.27	−0.41	154,000	179,714	45.8	47.1	80.5	3,366	+4,372	5.232	805,740	W., 1½		
17	33.78	−0.49												
18	33.57	−0.21												
19	33.35	−0.22	152,773	181,546	46.2	47.6	81.9	3,308	+1,832	5.125	782,964	N., 2	296	539
20	33.15	−0.20												
21	33.03	−0.12	150,311	180,139	45.7	47.3	81.1	3,292	−1,407	5.238	787,305	NE., 2		
22	32.86	−0.17												
23	32.45	−0.41	147,492	179,231	45.1	47.0	78.9	3,272	− 908	5.218	769,583	NE., 5		
24	32.13	−0.32												
25	31.75	−0.38	147,691	181,725	45.5	47.7	80.2	3,249	+2,494	4.893	722,621	NE., 1		
26	30.70	−1.05	143,343	180,740	44.9	47.4	78.6	3,193	− 985	4.772	684,160	E., 1		
27	29.77	−0.93	140,169	180,500	44.6	47.4	77.9	3,146	− 240	4.608	645,951	S., 1	333	444
28	28.51	−1.26	136,935	181,252	44.1	47.5	76.0	3,106	+ 752	4.495	615,522	S., 2		
Mar. 1	26.78	−1.73												
2	25.59	−1.19	125,527	178,804	41.9	46.9	72.5	2,996	−2,448	4.308	540,752	S., 3		
3	24.12	−1.47	120,885	178,590	40.9	46.8	70.8	2,961	− 214	4.348	525,636	S., 3		
4	23.47	−0.65	118,563	178,188	40.4	46.7	70.4	2,946	− 402	4.190	496,768	S., 3		
‖5	22.84	−0.63	119,189	153,977	41.3	45.9	67.8	2,888		4.112	490,118	Var., 3	333	555
6	22.25	−0.59	116,320	152,879	40.4	45.6	66.9	2,875	−1,098	4.079	474,516	NE., 3		
7	21.99	−0.26	115,738	153,082	40.3	45.7	66.8	2,871	+ 203	4.171	482,808	NW., 3		
8	21.99	0.00												
9	22.18	+0.19	119,739	156,421	41.8	46.7	67.2	2,860	+3,339	4.234	507,075	E., 10	333	365
10	22.53	+0.35	121,612	157,321	42.2	46.9	67.7	2,880	+ 900			W., 3		
11	23.07	+0.54	120,338	154,452	41.5	46.1	68.9	2,897	−2,869	4.394	528,821	S., 4		
12	23.73	+0.66	123,317	155,472	42.3	46.4	69.8	2,917	+1,020	4.375	539,556	SW., 20		
13	24.71	+0.98	124,329	153,505	42.3	45.8	69.4	2,939	−1,967	4.460	554,481	N., 6		
14	25.65	+0.94	128,860	155,331	43.0	46.3	70.7	2,995	+1,826	4.537	584,661	SW., 5		
15	26.84	+1.19												
16	27.99	+1.15	133,082	152,306	43.5	45.4	73.0	3,055	−3,025	4.786	636,878	Calm		
17	29.04	+1.05	138,278	154,247	44.6	46.0	75.3	3,100	+1,941	4.803	664,084	SW., 12	963	635
18	29.83	+0.79												
19	30.37	+0.54	140,459	152,238	44.6	45.4	75.8	3,155	−2,009	4.885	686,080	SW., 7		
20	31.14	+0.77												
21	31.90	+0.76	146,226	153,094	45.4	45.7	77.1	3,220	+ 856	4.936	721,822	Calm		
22	32.67	+0.77												
23	33.00	+0.33	148,722	151,025	44.8	45.0	78.4	3,321	−2,069	5.240	779,268	N., 12		

* Slough dis. = 3,002. † Slough dis. = 4,236. ‡ Slough dis. = 3,700. § Slough dis. = 6,640.
‖ New section.

Discharge observations at Warrenton, Miss.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope, sin. of inclination.	
			Area.		Depth.									
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.						Left bank.	Right bank.
1884.	*Ft.*	*Ft.*	*Sq. ft.*	*Sq. ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Sq. ft.*	*Ft.*	*Cu. ft.*			
24	33.44	+0.44	......	......	..	....	...	....	......	....	......	......	......	......
25	33.75	+0.31	......	......	..	....	...	....	......	....	......	......	......	......
26	33.99	+0.24	152,964	152,964	45.6	45.0	80.7	3,352	+1,930	5.285	808,361	SW., 4..	234	650
27	34.02	+0.03	......	......	..	..	...	....	......	....	......	......	......	......
28	33.99	—0.03	......	......	..	..	...	....	......	....	......	......	......	......
29	33.95	—0.04	......	......	..	..	...	....	......	....	......	......	......	......
30	33.65	—0.30	147,386	148,506	44.0	44.3	79.5	3,351	—4,458	5.178	763,004	SW., 4..	......	......
31	33.31	—0.34	149,831	151,104	44.7	45.1	79.3	3,331	+2,508	5.097	758,586	E., 2	370	635
Apr. 1	32.83	—0.48	149,100	152,965	45.0	45.6	79.3	3,313	+1,861	4.724	701,392	S., 8 ...	......	......
2	32.10	—0.67	......	......	..	..	...	....	......	....	......	......	......	......
3	31.86	—0.30	......	......	..	..	...	....	......	....	......	......	......	......
4	31.04	—0.82	141,002	150,743	43.4	45.0	76.8	3,251	—2,222	4.838	682,120	NW., 3 .	......	......
5	30.07	—0.97	......	......	..	..	...	....	......	....	......	......	......	......
6	29.14	—0.93	132,715	148,521	41.9	44.3	74.5	3,166	—2,222	4.799	636,883	(1), 12...	......	......

(e) Red River Landing, Louisiana.

Saint Louis, Mo., *April* 10, 1886.

Captain: I have the honor to submit the following report upon the final reduction of discharge observations made on the Mississippi River at Red River Landing, on Old River, connecting the Red and Mississippi rivers, and on the Atchafalaya River near Barbre's Landing. These observations were made between October 6, 1884, and March 31, 1885, by a party under the direction of Assistant Engineer Homer P. Ritter. Mr. E. L. Harman acted as recorder. A steam engineer and two boatmen completed the party.

(1) *Observations on the Mississippi River.*

Observations at this station were made upon a section about 300 feet below the warehouse at Red River Landing, and 100 feet below the section used in 1881-'82. The method of locating points on the section was as follows: At each end of the section a 1,000-foot base was measured at right angles to the section, and a system of ranges set to intersect the section at intervals of 200 feet, commencing at the base on the right bank. The signals on each bank were used out from that bank to the middle of the river. The positions of the greater part of the soundings were also determined by sextant angles to the base on the right bank. The distances of the water's edge from signals at each end were determined each day and determined the river's width.

The instruments in use at this station were Price meters B and No. 9, a break-current clock, electric batteries, transit, level, sextant, sounding leads and lines, etc. (The instruments and manner of using them were similar to those at Helena, which have already been described in my report on the reduction of work on that station.)

Meter B was used up to and including October 13. No observations were made for determining the coefficients of this meter for reducing registrations to velocity in feet per second, but early in January, 1885, Capt. Smith S. Leach and Assistant L. C. Jones made three series of observations for this purpose. These observations were made by moving the meter alternately up and down stream through running water over a known distance, and noting the times and numbers of registrations.

Let z = velocity of the water supposed constant,
c = velocity of the meter through space,
x = number of registrations per second,
y = velocity of the meter through the water, and
a and b = constants to be determined.

The observations have been reduced on the assumption that the relations of the quantities are expressed by the equations—

$$y = c - s = ax + b \text{ (when meter moves with the current),}$$
$$y = c + s = ax + b \text{ (when meter moves against the current.)}$$

The following table gives the result of the observations:

Station.	Date.	No. of observation.	*a*.	*b*.	Mean error of observation.
Arkansas City, Ark	Jan. 8	19	+1.784	+0.262	±0.059
Warrenton, Miss	Jan. 11	12	+1.772	+0.194	±0.085
Red River Landing, La	Jan. 14	13	+1.792	+0.262	±0.284

The means of the above results were used to reduce observations made with meter B, the equation being—

$$y = +1.783\,x + 0.239.$$

Meter No. 9 was used from October 15 to the end of the season. A series of thirteen observations was made in still water October 23, for determining the coefficients of this meter, but the observations were so discrepant that they have been rejected. A series of fifteen observations was made in still water for the same purpose November 8, which gave the following results:

$$y = +3.893\,x + 0.372.$$

A series of seventeen observations was made by Assistant L. C. Jones in running water January 14, which have been reduced by the method given above for meter B. The resulting equation is—

$$y = +4.029\,x - 0.016.$$

No subsequent observations were made to determine the coefficients of this meter, and it became necessary to adopt from these discrepant results some coefficients with which to reduce the velocity measurements. The coefficients in the two equations were combined, being given weight inversely as the squares of their mean errors and the following equation adopted to be used in reducing all measurements made with this meter:

$$y = +3.938\,x + 0.341.$$

In the notes no tests of lead line are recorded and no corrections given, and therefore none have been applied to the soundings. Prior to October 30 soundings were located by sextant angles to the 1,000-foot base on the right bank. These sections were plotted on cross-section paper with the horizontal scale 1 inch = 200 feet, and the vertical scale 1 inch = 10 feet. The depths were then scaled off from these sections at intervals of 100 feet and used in computing the areas. Subsequent to October 30 the locations of the soundings are given in the notes, both by the stations determined by the system of intersecting ranges and by sextant angles to the 1,000-foot base on the right bank. In many cases, however, the soundings have been located by the signals only. While the two locations do not exactly agree, yet the difference is not sufficient to materially change the area whichever method of location is used. If we suppose Δw to be the difference in location of a sounding by the two methods, and d_1 and d_2 the soundings either side of it, the difference in area caused by using one or the other of the locations will be

$$\Delta A = \tfrac{1}{2}\,\Delta w\,(d_1 - d_2).$$

As the form of the section used was such that the depths change very slowly except near the banks, the difference in the total area would be small whether one or the other location was used. While there is no doubt that the sextant angles give the better location, yet the work of computation of areas would be very much more using them than using the location by signals. The areas have therefore been computed, using the signal location of soundings, which supposes the soundings to be 100 feet apart. A number of areas have been computed, using each method of location, the differences between areas computed by the two methods being less than 1 per cent.

The notes subsequent to October 30 have been copied directly from the books on the computation sheets with the gauge-reading, width, and direction and force of wind. The distances of the end soundings from the water's edge were computed from the notes and copied on the sheets at the beginning and end of the series of soundings. The areas included between the end soundings and the shores were computed as right-angled triangles. The areas between soundings have been computed as if the section

of the bed between soundings was a right line. After all the areas between soundings had been computed, they were summed, and, with the end areas, gave the total water area of the section. The total area was then checked by being computed directly from the sum of the soundings. The two areas either side of a velocity station were then summed and gave the partial area pertaining to that velocity station. The sum of the partial areas gave the total area and formed a check on the computation of the partial areas.

The counting of the registrations of the meter had been done in the field, and the results were adopted in the office computation. The length of time of an observation for velocity is stated to have been not less than two minutes, but in the notes the number of registrations per minute is given. Up to and including October 13, which includes all observations taken with meter B, measurements for velocity were taken at mid-depth, while subsequent to that date they were taken at six-tenths of the depth from the surface, the launch not being anchored. The velocities observed at mid-depth have been divided by the coefficient 1.034 to reduce them to six-tenths depth velocities. This coefficient was obtained from the mean of all observations made in 1881 and 1882 on the form of the vertical curve of velocity of the five stations occupied. (See Report of Mississippi River Commission for 1884, p. 189.)

Prior to October 30 the points of velocity measurements on the section were located by sextant angles to the 1,000-foot base on the right bank. For this period the velocities have been plotted on the same sheets as the cross-sections, with the same horizontal scale and with a vertical scale of 1 inch = 1 foot per second. The transverse curves of velocities have been drawn and velocities scaled off at regular intervals of 200 feet to be used in computing the discharge. Subsequent to October 30 the velocities are given as being taken at the stations located by the intersecting ranges and have been copied directly on the computation sheets. Commencing with January 26 an additional velocity was measured about 50 feet from the right bank, and after February 18 an additional velocity was measured near the left bank. The velocities were computed from the registrations by means of a special table prepared for that purpose.

The partial areas were then multiplied by the corresponding velocities giving the partial discharges. The sum of the partial discharges gave the total discharge per second. The computation of areas and discharges were identical in form with that used in Helena, a sample of which is given in the report on reduction of observations at that station.

The results of the computation were then copied into the tabulation accompanying this report. The gauge-reading for days on which areas were measured were taken directly from the notes and correspond to the mean time of soundings. The readings given on other days are means of morning and evening readings and correspond to 12 m. The gauge read was established by this party about one-half mile above the regular gauge, and is said to have been at the same elevation. The rise or fall in twenty-four hours for any date is the difference between the mean gauge-readings for that day and the preceding one.

The computation of datum areas has been made in the following manner:

Datum was assumed to correspond to the gauge-reading 48.50 feet, that being the reading of the high water of 1882, and the same datum as used in the discharge work of 1881 and 1882. Datum width was taken as 3,918 feet. The maximum stage during the observations occurred February 4, 1885, when the gauge read 42.08 feet, and the observed width was 3,821 feet. The area of the section included between gauge-readings of 42.08 and 48.50 feet was computed as being 24,842 square feet. The slope of the banks was assumed to be uniform below the stage of 10 feet, between 10 and 20 feet, between 20 and 30 feet, between 30 and 40 feet, and between 40 and 42.08 feet, and the following widths adopted in computing datum areas: at 10 feet, 3,574 feet; at 20 feet, 3,650 feet; at 30 feet, 3,755 feet; and at 40 feet, 3,793 feet. Datum areas have then been computed by the following formulæ, w being observed width, and h gauge-reading:

Between 40 and 42.08 feet—

$$\text{Datum area} = 24{,}842 + (42.08 - h)\,\frac{3821 + w}{2} + \text{water area.}$$

Between 30 and 40 feet—

$$\text{Datum area} = 24{,}842 + (42.08 - 40.00)\,\frac{3821 + 3793}{2} + (40 - h)\,\frac{3793 + w}{2} + \text{water area.}$$

$$= 32{,}762 + (40 - h)\,\frac{3793 + w}{2} + \text{water area.}$$

Between 20 and 30 feet—

$$\text{Datum area} = 32{,}762 + (40 - 30)\,\frac{3793 + 3755}{2} + (30 - h)\,\frac{3755 + w}{2} + \text{water area.}$$

$$= 70{,}502 + (30 - h)\,\frac{3755 + w}{2} + \text{water area.}$$

Between 10 and 20 feet—

$$\text{Datum area} = 70{,}502 + (30-20)\frac{3755+3650}{2} + (20-h)\frac{3650+w}{2} + \text{water area.}$$

$$= 107{,}527 + (20-h)\frac{3650+w}{2} + \text{water area.}$$

Below 10 feet—

$$\text{Datum area} = 107{,}527 + (20-10)\frac{3650+3574}{2} + (10-h)\frac{3574+w}{2} + \text{water area.}$$

$$= 143{,}647 + (10-h)\frac{3574+w}{2} + \text{water area.}$$

It will be noticed that a large change takes place in the datum area between January 3 and January 6. The section of January 6 is shown on the plate accompanying this report in full lines, and that of January 3 by dotted lines. It will be seen by a comparison of these sections that this change is a nearly uniform increase across the section, the increase in mean datum depth being 2.4 feet. It is much to be doubted if such a change in the section really took place. The only note which has any relation to the subject is a statement in the journal that a new lead line was tagged January 5. It is also probable that a heavier lead came into use on January 6, as Assistant Ritter, in his report, states that he used "a 15-pound lead for ordinary stages, and a 20-pound lead for high stages." Whatever may have caused the change in datum area, an inspection of the datum area curve makes it evident either that the cause existed for some time prior to January 3, or else continued for some time after January 6.

Mean depth has been obtained by dividing the water area by the width, and mean datum depth by dividing the datum area by the datum width. Maximum depth has been taken directly from the soundings. Scour and fill have been obtained by taking differences of datum areas, scour being indicated by the positive sign.

Mean velocity has been obtained by dividing the discharge by the water area. During the higher stages of the river the partial discharges belonging to the velocity stations near the right bank approached 100,000 cubic feet per second. A change in the single measured velocity at one of those stations would therefore have a large effect on the total discharge, and it would seem desirable to have a greater number of measurements to determine so large a partial discharge.

The direction of the wind has been given in the notes with reference to the current, but in the tabulation the direction has been given with reference to the points of the compass. The force has been indicated as given in the observer's notes.

A number of slope observations were made by reading gauges on each bank approximately one-half mile above and below the section. As there is no means of determining the relative elevations of these gauges, except the statement that "they were set simultaneously at low water," the slope observations have not been reduced.

Accompanying this report is a plate on which are plotted the velocities, areas, and discharges as abscissas to gauge heights as ordinates, the scales being given on the plate. The mean gauge-readings and the datum areas have also been plotted in chronological order. The section as sounded January 6 is shown on the plate, also as sounded January 3. The gauge-readings, areas, discharges, mean velocities, and datum areas have also been plotted on another plate in chronological order for purposes of inspection and study.

(2) *Observations on Old River.*

Observations were made upon a section of about 2,000 feet below the foot of Turnbull Island. Assistant Ritter states that the section is the same as section H, which was sounded in 1882 by Assistant John Ewens, and in 1883 by Assistant Arthur Owen Wilson. (See Report Miss. River Com'n for 1884, p. 301.)

On the west bank a 300-foot base was measured at right angles to the section, and until January 2, soundings were located by transit angles, measured from the extremity of this base. On January 6 a new position, 280 feet from the section, was taken for the transit, which was used until January 17, when a 500-foot base was measured, also on the west bank, and soundings subsequent to that date located by sextant angles measured to signals at the extremities of this base.

The positions of velocity measurements, after and including January 17, were determined by sextant angles measured to the 500-foot base. The method of locating the velocity stations prior to that date is not stated, their distances from the banks in feet being given in the notes. Five velocity stations were usually occupied for each measured discharge.

The same instruments were used on this section as on the Red River Landing section, and the same coefficients have been used, both for reducing registrations of meters to

velocity in feet per second, and for reducing mid-depth velocities to six-tenths depth velocities.

The cross-sections have all been plotted on the horizontal scale, 1 inch = 100 feet, and vertical scale, 1 inch = 10 feet. The depths have then been scaled off at regular intervals of 100 feet, and with these scaled depths the areas have been computed in the same manner as already described for Red River Landing. The velocities have also been plotted on the cross-sections with the vertical scale, 1 inch = 1 foot per second, and the transverse curve of velocities drawn. Velocities were then scaled off at points mid-way between the scaled depths and multiplied into the included areas for the partial discharges. The sum of the partial discharges gave the total discharge.

The results of the computation were then copied into the tabulation accompanying this report. The gauge-readings are from a gauge at the section which was read at the beginning and end of an observation. The gauge was established November 1, its zero being 17.35 feet above Cairo Datum Plane. Readings prior to that date have been computed by adding 6.15 feet to the readings of the gauge in the main river. The quantity, 6.15 feet, is the mean difference between readings of the two gauges from November 1 to December 26, leaving out two days on which there was no current. The difference of readings between these dates varied from 6.00 to 6.38 feet, and as the current was in the same direction as during October, it is probable that the computed readings closely represent the stages at the section. As the gauge was read only when observations were made on the section, the rise or fall in 24 hours can not be given.

Datum areas have been computed in the following manner. Datum was assumed at the water surface on February 3, 1885, when the gauge read 48.41 and the width was 952 feet. All widths down to a stage of 44 feet have been taken as 952 feet. The slopes of the banks have been assumed uniform below 16 feet, between 16 and 26 feet, between 26 and 36 feet, between 36 and 40 feet, and between 40 and 44 feet. At 36 feet a large change in width takes place on account of the water overflowing the bar on the west bank. The width at 36 feet for computing areas above 36 feet has been taken as 828 feet, but for computing areas below 36 feet as 634 feet. The widths at stages of 40, 26, and 16 feet have been taken as 840, 610, and 520 feet respectively. Datum areas have then been computed by the following formulæ:

Between 44 and 48.41 feet—

$$\text{Datum area} = (48.41 - h)\ 952 + \text{water area.}$$

Between 40 and 44 feet—

$$\text{Datum area} = (48.41 - 44.00)\ 952 + (44 - h)\ \frac{952 + w}{2} + \text{water area.}$$

$$= 4{,}198 + (44 - h)\ \frac{952 + w}{2} + \text{water area.}$$

Between 36 and 40 feet—

$$\text{Datum area} = 4{,}198 + (44 - 40)\ \frac{952 + 840}{2} + (40 - h)\ \frac{840 + w}{2} + \text{water area}$$

$$= 7{,}782 + (40 - h)\ \frac{840 + w}{2} + \text{water area.}$$

Between 26 and 36 feet—

$$\text{Datum area} = 7{,}782 + (40 - 36)\frac{840 + 828}{2} + (36 - h)\frac{634 + w}{2} + \text{water area.}$$

$$= 11{,}118 + (36 - h)\frac{634 + w}{2} + \text{water area.}$$

Between 16 and 26 feet—

$$\text{Datum area} = 11{,}118 + (36 - 26)\frac{634 + 610}{2} + (26 - h)\frac{610 + w}{2} + \text{water area.}$$

$$= 17{,}338 + (26 - h)\frac{610 + w}{2} + \text{water area.}$$

Below 16 feet—

$$\text{Datum area} = 17{,}338 + (26 - 16)\frac{610 + 520}{2} + (16 - h)\frac{520 + w}{2} + \text{water area.}$$

$$= 22{,}988 + (16 - h)\frac{520 + w}{2} + \text{water area.}$$

From January 14 to February 18, inclusive, relatively large changes take place in the datum areas, some of which can not be taken as real changes in the section. The large datum area of January 14, for example, is caused by a widening of the entire section, which is not shown when the section is sounded January 17. The error in this case might be due to some error in the length of the base from which the dis-

aces were computed. Otherwise than the dates specified the datum areas show at the areas were measured with all necessary accuracy.
The remaining quantities in the tabulation have been obtained in the same manner similar quantities in the tabulation for Red River landing. As the stage in Old ver bears no relation to the velocities and discharges, they have not been plotted the usual manner. A table has been prepared which gives for each day during the riod of observations the reading of the standard gauge at Red River Landing. The ble also gives the measured discharges at Red River Landing and in Old River, and combining the two with proper regard to sign, the discharge of the Mississippi ove the mouth of Old River is obtained for days on which discharges were meased both at Red River Landing and in Old River.

(3) *Observations on the Atchafalaya River.*

Observations on the Atchafalaya River were made on a section about 3,000 feet low its head. Assistant Ritter states that it is the same section as was used in 1881 d 1882, but he mistook a signal marking a caving-stake as indicating the position the old section. While the two sections are near each other they can not be taken being identical. The statement made in the first tables of discharge results sent t, that areas had increased since 1882, was based on the supposition that the same tion had been used.
A 500-foot base at right angles to the section was measured on the left bank, and undings were located by means of a transit at the extremity of the base. Veity stations were located by means of sextant angles to the base. The same instrunts were used at this section as at Red River Landing, and the same coefficients ve been used for reducing registrations to velocities in feet per second. Velocities re measured at six-tenth depth, the launch not being anchored.
The cross-sections have been plotted on a scale of 1 inch=100 feet, and a vertical scale 1 inch = 10 feet. The depths have then been scaled off at regular intervals of 100 t, and, with these scaled depths, the areas have been computed in the same manr as already described for Red River Landing.
The velocities have also been plotted on the cross-sections with the vertical scale 1 inch = 1 foot per second, and the transverse curve of velocities drawn. Velocities re then scaled off at points midway between the scaled depths and multiplied into e included areas for the partial discharges, the sum of which gave the total disarge.
The results were then copied into the tabulation accompanying this report. The nge-readings given in the second column were taken from a gauge at the section ablished by Assistant Ritter. The elevation of this gauge with reference to a nchmark is given in the notes, and this bench-mark has since been connected with ench-mark at Barbre's Landing. This connection makes zero of gauge at section 10 feet below zero of Barbre's Landing gauge, or, taking the elevation of the latter 24.17 feet above Cairo Datum, the zero of the gauge at the section would be 21.93 low Cairo Datum. The gauge-readings in the third column are the readings at rbre's Landing increased by 1.1 feet to make them correspond as nearly as possible th the readings given in the published results of discharge measurements at this tion in 1881 and 1882.
The water-surface on February 3, 1885, has been assumed as datum, the gauge-reads on that day being 87.11 feet, and width 871 feet. Datum areas have then been mputed by the following formula:

$$\text{Datum Area} = \frac{871 + w}{2}(87.11 - h) + \text{water area.}$$

The remaining quantities in the table have been obtained in the usual manner.
Very respectfully, your obedient servant,

L. L. WHEELER,
In charge Computing Division.

Capt. THOMAS TURTLE,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

Discharge observations at Red River Landing, Louisiana.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1884.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu. ft.*	
Oct. 1	......	......	......	......	......	......	......	......	......	......	......	
2	......	......	......	......	......	......	......	......	......	......	......	
3	......	......	......	......	......	......	......	......	......	......	......	
4	......	......	......	......	......	......	......	......	......	......	......	
5	7.65	......	......	......	......	......	......	......	......	......	......	
6	8.20	+0.77	98,926	248,997	27.8	63.4	43.0	3,564	......	2.530	250,252	Calm.
7	9.50	+1.24	108,509	253,941	30.4	64.7	46.0	3,568	+4,944	2.477	268,829	Do.
8	10.90	+1.46	110,830	251,263	30.9	64.0	47.0	3,582	−2,678	2.626	290,982	Do.
9	12.70	+1.39	123,685	257,653	34.4	65.7	49.0	3,594	+6,390	2.748	339,900	N., stron
10	13.60	+1.21	125,408	256,141	34.8	65.3	51.0	3,605	−1,512	2.674	335,264	N., sligh
11	14.60	+0.98	122,934	250,060	34.1	63.7	51.0	3,609	−6,081	2.754	338,529	Do.
12	15.53	+0.83	......	......	......	......	......	......	......	......	......	
13	16.10	+0.66	129,189	250,887	35.7	63.9	50.4	3,617	+ 827	2.954	381,627	Do.
14	16.64	+0.45	......	......	......	......	......	......	......	......	......	
15	16.80	+0.14	128,186	247,345	35.4	63.0	51.5	3,620	−3,542	3.079	394,637	Do.
16	16.70	−0.12	131,020	250,542	36.2	63.8	54.0	3,620	+3,197	3.070	402,252	Do.
17	16.40	−0.30	130,262	250,873	36.0	63.9	51.0	3,619	+ 331	2.982	388,460	Calm.
18	16.05	−0.34	127,835	249,714	35.3	63.6	51.0	3,617	−1,159	2.928	374,335	N., sligh
19	15.72	−0.30	......	......	......	......	......	......	......	......	......	
20	15.50	−0.26	123,982	247,853	34.3	63.2	50.0	3,614	−1,861	2.963	367,365	S., sligh
21	15.34	−0.12	126,633	251,085	35.0	64.0	52.2	3,614	+3,232	2.979	377,232	Do.
22	15.35	+0.01	124,527	248,943	34.4	63.4	50.0	3,614	−2,142	2.958	368,301	Calm.
23	15.35	0.00	......	......	......	......	......	......	......	......	......	
24	15.41	+0.04	125,181	249,381	34.6	63.5	49.0	3,615	+ 438	2.925	366,193	N., sligh
25	15.40	+0.01	126,396	250,632	35.0	63.9	52.0	3,615	+1,251	2.923	369,473	S., sligh
26	15.53	+0.13	......	......	......	......	......	......	......	......	......	
27	15.40	−0.10	128,097	252,333	35.4	64.3	52.0	3,615	+1,701	......	......	
28	15.18	−0.28	127,010	252,041	35.2	64.2	52.2	3,613	− 292	2.873	364,955	NE., str
29	14.87	−0.28	......	......	......	......	......	......	......	......	......	
30	14.60	−0.31	125,507	252,636	34.8	64.4	51.5	3,610	+ 595	2.776	348,367	N., bris
31	14.25	−0.33	124,094	252,476	34.4	64.3	50.5	3,604	− 160	2.841	352,567	Calm.
Nov. 1	14.00	−0.24	128,237	257,529	35.6	65.6	52.1	3,605	+5,053	2.797	358,612	Do.
2	13.83	−0.16	......	......	......	......	......	......	......	......	......	
3	13.80	−0.03	......	......	......	......	......	......	......	......	......	
4	13.85	+0.05	126,469	256,302	35.1	65.3	51.2	3,604	−1,227	2.788	352,540	Do.
5†	13.87	+0.03	124,768	254,528	34.6	64.9	51.9	3,604	−1,774	2.751	342,904	NE., ——
6†	13.87	−0.01	124,817	254,581	34.6	64.9	50.9	3,605	+ 53	2.759	344,185	NE., ——
7	13.78	−0.09	121,860	251,960	33.8	64.2	49.0	3,605	−2,631	2.747	334,771	N., ——
8	13.69	−0.10	123,019†	253,436	34.1	64.0	50.2	3,605	+1,486	2.710	333,296	Calm
9	13.56	−0.12	......	......	......	......	......	......	......	......	......	
10	13.38	−0.20	121,116	252,637	33.6	64.4	50.2	3,599	− 799	2.665	322,701	Do.
11	13.14	−0.26	118,798	251,193	33.0	64.0	48.1	3,600	−1,444	2.670	317,32[illegible]	Do
12	12.79	−0.34	117,440	251,089	32.7	64.0	48.0	3,596	− 104	2.721	319,506	S., slight
13	12.43	−0.37	115,410	250,340	32.1	63.8	47.2	3,590	− 749	2.625	302,905	N., sligh
14	11.98	−0.44	113,908	250,447	31.8	63.8	47.1	3,585	+ 107	2.642	300,961	Do
15	11.50	−0.47	113,257	251,528	31.6	64.1	47.5	3,584	+1,081	2.553	289,024	Calm
16	11.04	−0.44	......	......	......	......	......	......	......	......	......	
17	10.55	−0.49	110,888	252,567	31.0	64.4	46.[illegible]	3,578	+1,039	2.606	288,888	N., sligh
18	10.20	−0.41	108,263	251,163	30.3	64.0	44.[illegible]	3,569	−1,404	2.606	282,187	N., ——
19	9.70	−0.46	107,570	252,288	30.2	64.3	45.0	3,569	+1,125	2.428	261,276	N., stron
20	9.30	−0.40	104,620	250,766	29.3	63.9	44.[illegible]	3,567	−1,522	2.489	260,341	N., sligh
21	8.97	−0.33	103,304	250,628	29.0	63.9	44.2	3,566	− 138	2.504	258,597	S., slight
22	8.72	−0.23	......	......	......	......	......	......	......	......	......	
23	8.68	−0.04	......	......	......	......	......	......	......	......	......	
24*	8.38	−0.33	101,260	250,687	28.4	63.9	43.6	3,563	+ 59	2.434	246,502	N., ——
25*	8.15	−0.20	100,433	250,680	28.2	63.9	43.0	3,561	− 7	2.377	238,553	S., strong
26	8.02	−0.14	98,963	249,673	27.8	63.6	42.5	3,560	−1,007	2.328	230,397	N., brisk
27	7.93	−0.08	......	......	......	......	......	......	......	......	......	
28‡	7.89	−0.05	100,029	251,201	28.1	64.0	42.5	3,559	+1,528	2.247	224,746	N., stron
29*	7.77	−0.14	97,589	249,189	27.4	63.5	40.3	3,559	−2,012	2.349	229,218	S., ——
30	7.61	−0.13	......	......	......	......	......	......	......	......	......	
Dec. 1	7.50	−0.12	98,764	251,322	27.8	64.0	41.9	3,555	+2,133	2.396	236,644	S., slight
2	7.52	+0.03	98,650	251,138	27.7	64.0	42.0	3,556	− 184	2.381	231,911	Calm.
3	7.68	+0.20	98,423	250,343	27.7	63.8	42.2	3,558	− 795	2.360	232,162	S., slight
4	8.10	+0.40	101,589	252,013	28.5	64.2	43.0	3,560	+1,670	2.496	253,641	S., brisk.
5	8.90	+0.78	......	......	......	......	......	......	......	......	......	
6	9.57	+0.67	105,197	250,381	29.4	63.8	44.0	3,574	−1,632	2.443	256,955	W., sligh
7	9.92	+0.35	......	......	......	......	......	......	......	......	......	
8	10.01	+0.09	107,135	250,746	29.9	63.9	45.5	3,578	+ 365	2.464	263,908	S., slight

* River rough. Water rough. ‡ River very rough.

Discharge observations at Red River Landing, Louisiana—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1884.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet.	Feet.	Sq. ft.	Feet.	Cu. ft.	
Dec. 9	9.99	−0.03	107,042	250,725	29.9	63.9	45.1	3,578	− 21	2.424	259,264	N., slight.
10	9.82	−0.18	105,672	249,963	29.5	63.7	45.2	3,578	− 762	2.474	261,638	Calm.
11*	9.60	−0.20	106,013	251,090	29.6	61.9	45.1	3,578	+1,127			S., strong.
12*	9.36	−0.31	103,542	249,477	28.9	63.6	45.0	3,576	−1,613	2.475	256,316	NW., strong.
13*	8.69	−0.65	102,393	250,722	28.6	61.9	44.5	3,574	+1,245	2.335	239,130	NE., strong.
14	8.49	−0.15										
15	8.51	+0.02										
16	8.02	−0.45	100,232	251,340	28.2	63.9	44.0	3,558	+ 218	2.335	233,800	S., slight.
17	7.66	−0.30										
18	7.92	+0.26										
19	8.75	+0.80	102,007	250,118	28.6	63.7	44.0	3,569	− 822	2.464	251,268	Calm.
20*	10.00	+1.33	107,205	250,652	29.9	63.9	45.5	3,576	+ 534	2.721	291,182	S., strong.
21	11.87	+1.72										
22	13.20	+1.43	118,130	250,324	32.8	63.8	47.0	3,605	− 328	2.811	332,134	W., slight.
23	14.40	+1.20	121,962	249,820	33.8	63.7	49.5	3,611	− 504	2.757	336,310	Calm.
24*	15.25	+0.77	125,763	250,549	34.8	63.8	48.4	3,617	+ 720	2.878	361,904	N., strong.
25	15.77	+0.50										
26*	16.00	+0.27	128,270	250,347	35.4	63.8	51.2	3,625	− 202	2.732	350,484	N., strong.
27	16.15	+0.11										
28	16.30	+0.15										
29	17.05	+0.75										
30	18.40	+1.21	136,744	250,105	37.5	63.7	52.5	3,643	− 242	3.080	421,182	S., slight.
31	19.55	+1.26	141,202	250,371	38.7	63.8	55.0	3,640	+ 266	3.179	448,798	N., strong.
1885.												
Jan. 1	20.45	+0.93										
2*	21.20	+0.93	145,922	249,050	39.9	63.5	57.0	3,660	−1,821	3.318	484,173	N., strong.
3	22.90	+1.77	153,735	250,578	41.9	63.9	58.0	3,667	+1,528	3.395	521,820	N., slight.
4	25.37	+2.22										
5	27.57	+2.20										
6	29.45	+2.10	187,786	260,352	50.0	66.3	68.0	3,751	+9,774			W., strong.
7	31.40	+1.84	196,744	261,975	52.4	66.8	69.5	3,758	+1,623			S., slight.
8	32.85	+1.36	202,154	261,922	53.7	66.7	73.0	3,761	− 53	4.087	826,130	E., brisk.
9	34.12	+1.26	204,444	259,441	54.2	66.1	75.0	3,770	−2,481	4.068	831,591	S., strong.
10	35.08	+1.03	209,701	261,073	55.6	66.5	75.1	3,772	+1,632	4.273	896,039	S., slight.
11	36.00	+0.84										
12	36.65	+0.65	217,088	262,531	57.5	66.9	77.0	3,778	+1,458			S., slight.
13	37.21	+0.55	218,241	261,569	57.7	66.7	77.0	3,781	− 962	4.449	971,041	N., slight.
14	37.62	+0.42										
15	37.94	+0.32										
16	38.75	+0.73	227,277	264,778	60.0	67.5	81.0	3,790	+3,209			NW., strong.
17	39.07	+0.43	225,675	261,964	59.6	66.8	80.0	3,791	−2,814	4.642	1,047,621	N., strong.
18	39.37	+0.27										
19	39.68	+0.33	224,236	258,212	59.1	65.8	79.5	3,792	−3,752	4.783	1,072,620	N., slight.
20	39.95	+0.25										
21	40.23	+0.30	226,708	258,593	59.8	65.9	81.0	3,793	+ 381	4.855	1,100,586	N., strong.
22	40.52	+0.28	228,193	258,975	60.1	66.0	80.5	3,794	+ 382	4.951	1,129,784	NE., strong.
23	40.90	+0.37										
24	41.16	+0.26										
25	41.36	+0.20										
26	41.53	+0.17	229,338	256,290	60.1	65.3	82.5	3,815	−2,605	4.882	1,119,520	N., slight.
27	41.67	+0.14	232,798	259,206	61.0	66.1	82.0	3,817	+2,926	4.871	1,133,970	S., slight.
28	41.77	+0.10										
29	41.85	+0.08	228,741	254,462	59.9	64.9	79.0	3,819	−4,744	4.928	1,127,208	SE., strong.
30	41.91	+0.06	230,562	256,058	60.4	65.3	79.2	3,819	+1,591	5.077	1,170,641	S., slight.
31	41.99	+0.08										
Feb. 1	42.00	+0.01										
2	42.06	+0.05	228,582	253,500	59.8	64.6	87.0	3,821	−2,553	4.953	1,132,279	Calm.
3	42.06	+0.01										
4	42.08	+0.02	232,520	257,722	60.8	65.7	85.5	3,821	+4,222	5.037	1,171,296	N., slight.
5	42.07	−0.01	236,688	261,568	61.9	66.7	85.5	3,822	+3,846	4.954	1,172,610	N., strong.
6	42.06	−0.01	232,178	257,096	60.8	65.5	87.0	3,822	−4,472	4.896	1,136,794	S., slight.
7	41.97	−0.09	232,287	257,549	60.8	65.6	84.5	3,822	+ 453	4.867	1,130,443	S., brisk.
8	41.77	−0.20										
9	41.60	−0.20	229,861	256,536	60.2	65.4	84.5	3,818	−1,013			N., strong.
10	41.37	−0.22	235,300?	262,853	61.7	67.0	92.0	3,816	+6,317	4.729	1,112,775	Do.
11	40.95	−0.38	228,958	258,108	60.2	65.8	89.0	3,804	−4,745	4.556	1,043,233	N., slight.
12	40.65	−0.30	229,628	259,905	60.4	66.3	87.0	3,800	+1,887	4.586	1,053,166	N., brisk.
13	40.28	−0.41										
14	39.85	−0.45	223,626	256,956	59.0	65.5	86.0	3,792	−3,039	4.376	978,660	N., slight.

* River rough.

Discharge observations at Red River Landing, Louisiana—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.									
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.	Sour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
1885.	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Cu. ft.*	
Feb. 15	39.37	—0.44	......	......	......	......	......	......	......	......	......	
16	39.00	—0.42	223,038	259,592	58.8	66.2	86.5	3,792	+2,636	4.227	942,868	S., slight
17	38.59	—0.40	220,544	258,651	58.2	65.9	87.0	3,788	— 941	4.373	964,477	Do.
18	38.18	—0.38	220,351	260,012	58.2	66.3	88.0	3,788	+1,361	......	......	N., stron
19	37.87	—0.32	212,281	253,117	56.0	64.5	86.0	3,788	—6,805	4.174	885,963	N., brisk
20	37.67	—0.21	216,454	258,047	57.2	65.8	84.5	3,787	+4,9 0	4.086	884,464	N., stron
21	37.42	—0.22	215,384	257,923	56.9	65.7	84.0	3,786	— 124	4.044	871,041	N., brisk
22	37.25	—0.17	......	......	......	......	......	......	......	......	......	
23	37.02	—0.24	212,823	256,875	56.2	65.5	84.0	3,784	—1,048	......	......	S., brisk.
24	36.96	—0.07	212,288	256,567	56.1	65.4	86.5	3,784	— 308	4.100	870,440	N., slight
25	36.90	—0.07	212,514	257,017	56.2	65.5	84.0	3,782	+ 450	4.062	863,257	N., brisk.
26	36.50	—0.37	......	......	......	......	......	......	......	......	......	
27	36.07	—0.48	209,791	257,422	55.6	65.6	83.1	3,774	+ 405	3.884	814,860	Calm.
28	35.49	—0.62	207,321	257,138	55.0	65.5	80.9	3,770	— 284	3.827	793,471	Calm.
Mar. 1	34.72	—0.68	......	......	......	......	......	......	......	......	......	
2	34.09	—0.72	201,098	256,206	53.4	65.3	81.1	3,769	— 932	3.625	728,987	N., slight
3	33.25	—0.87	198,416	256,693	52.7	65.4	79.5	3,767	+ 487	3.555	705,305	S., slight.
4	32.26	—0.87	......	......	......	......	......	......	......	......	......	
5	31.46	—0.94	190,535	255,561	50.6	65.1	79.1	3,763	—1,132	3.482	663,393	Calm.
6	30.60	—0.80	189,394	257,650	50.4	65.7	79.0	3,759	+2,089	3.366	637,536	N., slight
7	29.99	—0.62	185,773	256,313	49.5	65.3	77.0	3,750	—1,337	3.435	638,168	Calm.
8	29.36	—0.54	......	......	......	......	......	......	......	......	......	
9	29.01	—0.39	179,167	253,385	47.8	64.6	75.0	3,753	—2,928	3.444	617,062	S., slight.
10	28.73	—0.24	......	......	......	......	......	......	......	......	......	
11	28.61	—0.13	178,599	254,311	47.7	64.8	78.0	3,741	—+926	3.498	624,733	Do.
12	28.67	+0.07	......	......	......	......	......	......	......	......	......	
13	28.86	+0.21	176,233	251,019	47.1	64.0	77.5	3,743	—3,292	3.525	621,226	N., slight.
14	29.16	+0.33	179,701	253,354	48.0	64.6	74.1	3,748	+2,335	3.469	623,463	S., slight.
15	29.74	+0.53	......	......	......	......	......	......	......	......	......	
16	30.33	+0.59	......	......	......	......	......	......	......	......	......	
17	30.94	+0.61	......	......	......	......	......	......	......	......	......	
18	31.48	+0.56	189,873	254,845	50.4	64.9	76.5	3,768	+1,491	3.766	715,087	N., strong
19	31.95	+0.49	195,578	258,785	51.9	66.0	79.0	3,771	+3,940	3.797	742,687	N., slight.
20	32.40	+0.46	197,955	259,460	52.5	66.1	79.0	3,771	+ 675	3.827	757,562	Do.
21	33.10	+0.56	200,276	259,137	53.1	66.0	80.5	3,772	— 323	3.839	768,839	Calm.
22	33.60	+0.59	......	......	......	......	......	......	......	......	......	
23	33.97	+0.88	202,289	257,866	53.6	65.7	82.5	3,774	—1,271	3.848	778,413	N., strong.
24	34.29	+0.37	203,262	257,631	53.8	65.7	84.1	3,775	— 235	4.079	829,005	Calm.
25	34.70	+0.35	......	......	......	......	......	......	......	......	......	
26	35.03	+0.33	......	......	......	......	......	......	......	......	......	
27	35.32	+0.29	......	......	......	......	......	......	......	......	......	
28	35.41	+0.09	......	......	......	......	......	......	......	......	......	
29	35.51	+0.10	......	......	......	......	......	......	......	......	......	
30	35.41	—0.09	204,896	255,031	54.2	65.0	84.5	3,777	—2,600	3.933	805,848	N., slight.
31	35.30	—0.12	......	......	......	......	......	......	......	......	......	

Discharge observations in Old River, near Red River Landing, Louisiana.

1884.												
Oct. 8*	17.47	....	6,426	28,746	11.5	30.2	19.0	558	....	1.764	11,334	
9	18.75	....	7,851	28,868	13.1	30.3	19.0	559	+ 122	2.171	15,964	S., strong
10	19.85	....	8,427	29,363	15.0	30.8	20.0	560	+ 495	2.526	21,287	E., slight.
13	22.40	....	9,780	29,233	17.3	30.7	22.0	565	— 130	2.966	29,013	N., slight.
15	22.95	....	10,327	29,463	18.1	30.9	24.0	569	+ 230	3.106	32,086	Calm.
17	22.47	....	9,788	29,192	17.3	30.7	23.0	566	— 271	2.799	27,395	Do.
22	21.50	....	9,147	27,120	16.2	30.6	24.0	565	— 63	2.695	24,662	N., light.
25	21.55	....	9,445	29,395	16.7	30.9	20.0	564	+ 266	2.680	25,304	Calm.
Nov. 1	20.00	....	8,722	29,528	16.0	31.0	19.1	546	+ 133	2.458	21,440	Do.
7	19.80	....	7,941	28,866	14.5	30.3	20.5	547	— 662	2.556	20,301	N., slight.
14	18.00	....	7,158	29,112	13.2	30.6	16.5	544	+ 246	1.990	14,241	Do.
19	15.77	....	5,743	28,851	11.0	30.3	14.2	522	— 261	1.420	8,158	Do.
21	15.07	....	5,871	28,843	10.3	30.3	13.7	520	— 8	1.582	8,505	Calm.
24	14.45	....	4,515	28,301	8.9	29.7	12.4	510	— 542	1.309	5,911	Do.
29	13.85	....	4,123	28,207	8.2	29.6	11.5	500	— 94	1.242	5,120	S.
Dec. 1	13.61	....	4,134	28,339	8.3	29.8	11.9	498	+ 132	1.304	5,387	S., slight.
5	15.11	....	4,902	28,353	9.4	29.8	11.9	519	+ 14	1.669	8,178	Calm.
6	15.75	....	5,061	28,179	9.8	29.6	14.0	518	— 174	1.741	8,811	S., slight.
8	16.18	....	5,413	28,307	10.4	29.7	14.0	520	+ 128	1.606	8,687	Calm.

* From Mississippi River.

Discharge observations at Red River Landing, Louisiana—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	Reading.	Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.					
1884.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet.	Feet.	Sq. ft.	Feet.	Cu. ft.	
Dec. 10	15.95	....	5,498	28,512	10.6	29.9	14.8	519	+ 206	1.473	8,101	S., slight.
12	15.45	....	5,249	28,519	10.4	30.0	14.0	507	+ 7	1.263	6,635	N., slight.
13	14.86	....	4,918	28,487	9.7	29.9	13.0	508	— 32	1.166	5,734	N., strong.
16*	14.31	....	4,456	28,306	8.9	29.7	11.5	500	— 181	.....	....	S., slight.
17*	14.08	....	4,198	28,152	8.4	29.6	10.5	497	— 144	.....	....	Calm.
19†	15.27	....	5,292	28,568	10.1	30.0	13.0	516	— 406	0.961	5,002	Do.
20	16.52	....	5,563	28,819	10.4	29.7	15.0	533	— 249	1.416	7,878	S., strong.
22	19.71	....	7,729	28,693	14.2	30.1	18.4	543	+ 374	1.870	14,446	W., brisk.
23	20.83	....	8,218	28,549	15.0	30.0	20.0	548	— 144	1.812	14,891	N., slight.
24	21.56	....	8,901	28,829	16.1	30.3	19.8	554	+ 280	1.744	15,523	N., strong.
26	22.28	....	8,814	28,332	15.7	20.7	20.5	562	— 497	1.467	12,929	N., slight.
30‡	24.73	....	10,867	28,975	18.0	30.4	22.9	602	+ 643	3.676	39,956	S., strong.
31	26.45	....	11,961	29,024	19.6	30.5	27.0	611	+ 49	5.289	63,271	N., strong.
1885.												
Jan. 2	28.25	....	12,493	28,490	20.0	29.9	30.0	625	— 534	5.349	66,829	N., slight.
6	36.25	....	18,103	28,412	27.7	29.8	35.9	654	— 78	1.520	27,514	W., strong.
7	37.58	....	19,280	28,901	28.4	30.4	36.9	680	+ 489	0.871	16,786	Calm.
10†	41.47	....	22,970	29,427	27.5	30.9	41.8	834	+ 526	0.880	20,220	S., slight.
14	43.88	....	26,835	31,144	29.8	32.7	44.0	900	+1,717	0.767	20,580	Do.
17	45.31	....	25,260	28,211	26.3	29.6	42.0	960	—2,933	1.137	28,725	Do.
19	45.91	....	26,870	29,250	28.0	30.7	43.5	960	+1,039	0.841	22,596	S., strong.
23*	47.12	....	27,930	29,158	29.1	30.6	44.0	960	— 92	.....	....	Calm.
27‡	47.98	....	29,964	30,373	31.4	31.9	45.0	955	+1,215	1.121	33,575	N., strong.
29	48.19	....	29,661	29,870	31.1	31.4	45.1	955	— 503	0.743	22,038	N., slight.
Feb. 3	48.41	....	28,890	28,890	30.3	30.4	46.0	952	— 980	1.061	30,639	Do.
5	48.38	....	27,515	27,544	28.9	28.9	45.0	958	—1,346	1.191	32,787	N., strong.
10	47.60	....	28,587	29,358	30.3	30.8	47.0	945	+1,814	1.556	41,501	S., strong.
18	44.56	....	26,778	30,453	28.1	32.0	44.0	952	+1,095	2.869	76,846	Do.
23	43.40	....	24,581	29,829	27.9	30.8	41.0	882	—1,124	2.318	56,979	N., slight.
25	43.22	....	24,693	29,604	28.2	31.1	41.0	877	+ 275	2.106	53,604	S., slight.
27	42.38	....	24,929	30,603	28.7	32.1	41.5	870	+ 999	2.819	70,283	Calm.
Mar. 5	37.71	....	21,004	30,698	25.3	32.2	37.5	830	+ 95	4.719	99,125	Do.
7	36.31	....	19,204	30,063	23.2	31.6	36.5	831	— 635	5.069	97,354	S., slight.
18	38.02	....	20,212	29,655	24.1	31.1	36.5	838	— 408	0.733	14,823	Calm.
19	38.41	....	19,882	28,996	23.8	30.5	36.0	835	— 659	0.385	7,652	Do.
23†	40.30	....	21,384	28,905	25.3	30.4	38.5	844	— 91	0.780	16,685	S., strong.
27	41.55	....	22,547	28,966	26.2	30.4	38.0	861	+ 61	1.144	25,787	N., brisk.
28	41.60	....	22,291	28,663	25.9	30.1	37.5	861	— 301	1.110	24,751	Do.
30	41.70	....	22,231	28,517	25.7	30.0	39.5	864	— 148	1.065	23,458	Calm.
31	41.55	....	21,790	28,218	25.3	29.6	38.5	861	— 299	0.936	20,412	N., slight.

* No current. † From Mississippi River. ‡ Toward Mississippi River.

Discharge observations at head of Atchafalaya River.

Date.	Gauge reading.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	At section.	At Barbreα, +1.1 feet.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.					
1885.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet.	Feet.	Sq. ft.	Feet.	Cu. ft.	
Jan. 31	37.00	42.6	37,357	37,453	43.0	43.0	86.0	869	....	......	....	N., slight.
Feb. 3	37.11	42.7	36,564	36,564	42.0	42.0	84.5	871	— 889	5.317	194,416	S., slight.
6	37.06	42.7	37,156	37,182	42.7	42.7	82.0	870	+ 618	5.715	212,344	E., slight.
14	35.12	40.7	36,054	37,780	41.7	43.4	83.0	861	+ 598	4.943	178,204	S., slight.
19	33.33	38.9	35,350	38,620	41.2	44.3	82.0	859	+ 840	5.298	187,290	N., brisk.
26	32.04	37.6	33,297	37,617	40.0	43.2	85.1	833	—1,003	4.537	151,075	N., slight.
Mar. 10	75.75	31.1	27,262	36,674	34.7	42.1	73.1	786	— 943	3.916	106,746	Calm.
20	77.68	33.1	29,753	37,599	37.5	43.2	75.1	793	+ 925	4.342	129,200	E., slight.

(*f*) CARROLLTON, LOUISIANA.

SAINT LOUIS, *November* 2, 1886.

CAPTAIN: I have the honor to submit the following report upon the final reduction of discharge observations made on the Mississippi River at Carrollton, La., between October 8, 1884, and March 28, 1885.

The party at this station was under the direction of Assistant Engineer M. K. Bowen. Mr. J. O. Hassam acted as recorder throughout the season. A steam engineer and two boatmen completed the party.

Observations were made upon a section, which a sketch sent to this office by Mr. Bowen shows to have been about 1,800 feet below the Cambronne Sections used in 1879 and 1880. There is nothing in the notes which locates the section more definitely. The ends of the section were marked by signals, and along the right bank a series of signals at right angles to the section were set to locate positions on the section by means of a sextant set at the constant angle of 14° 02′. (For further explanation of this method of location, see Report Mississippi River Commission for 1883, page 181.)

The instruments in use at this station consisted of Price meter No. 6, a Morse register, a break-circuit clock, electric batteries, transit, level, sextant, sounding leads and lines, etc. (The instruments and manner of using them were similar to those at Helena, which have already been described in my report on the reduction of work at that station.)

The coefficients to be used in reducing registrations of the meter to velocity in feet per second depend upon two determinations made February 4 and 20, 1885. In his reports to the office of work performed, Mr. Bowen states that a third rating was made October 3, 1884, in Harvey's Canal, but the notes of this rating are not given in the note-books, and the results obtained are not known. The ratings were made in still water and have been reduced in the usual manner.

The following table contains the results of the ratings used:

Date.	No. of observations.	a.	b.	Mean error of observation.	Mean error of a.	Mean error of b.
February 4, 1885	15	+ 3.910	+ 0.184	± 0.138	± 0.044	± 0.069
February 20, 1885	13	+ 4.020	+ 0.250	± 0.082	± 0.039	± 0.043

In reducing the observed velocities in the discharge measurements the arithmetical means of the values of a and b have been adopted and the equation between the variables becomes

$$y = 3.965\,x + 0.217.$$

In this equation, $x =$ number of registrations per second, and $y =$ velocity in feet per second. These values have been used throughout the entire series of observations. The counting of registrations of the meter had been done in the field, and the results were adopted in the office reduction. The launch was not anchored in measuring velocities at this station. The computation of velocities as far as possible was made by means of tables prepared for the purpose, but the labor of computation was largely increased by the irregularity in times of the observations.

Up to October 29 observations for velocity were made at mid-depth, and subsequent to that date at six-tenths the depth from the surface. The observations at mid-depth have been reduced to correspond to those taken at six-tenth depth by dividing the discharge by the coefficient 1.035, that being the relation obtained by Assistant W. G. Price, in 1883, between velocities at those depths at this station. (See observations taken from July 1 to September 7, Report Mississippi River Commission for 1883, page 472.) Velocities were measured at points on the cross-section 120 feet apart, except near the banks and near the middle of stream where the points were 80 and 100 feet apart. The manner of locating the velocity stations is not stated.

The soundings were taken at irregular intervals, and were located by the series of signals on the right bank. In the field two sets of note-books had been kept, one of which contained the original notes in a very confused condition, while in the other the notes had been copied in the order of their dates. In the original notes the lead-line corrections are given, but in the copied notes the corrections had been applied to the soundings. The application of these corrections has been examined on many dates and found to have been correctly made. The reduction has been made from the second set of notes, but even in these many of the figures were scarcely legible.

The soundings have been plotted on a horizontal scale of 1 inch = 200 feet, and a vertical scale of 1 inch = 20 feet and the cross-sections drawn. Depths were then scaled off at the points of velocity measurements and at points midway between them. Near the banks actual soundings were taken in sufficient number to give the end areas with necessary accuracy. As by this method of computation the depths were not at regular intervals and the areas could not be checked by computing the total area from the sum of the soundings, it was decided to perform the computation in duplicate. The computation of areas and discharges were made in the usual manner, and the results of the two computations made to agree. All differences were examined and errors corrected. Many of the differences came from a different interpretation of the notes. Some of these differences could be settled by reference to the original notes, but such as could not were settled arbitrarily. In some few instances the notes have been corrected arbitrarily where they were evidently largely in error.

On a large number of days velocities were observed but no soundings were taken. There seems to have been no good reasons for this, as on many days the notes show that the weather was fair and suitable for work, while the velocity measurements occupied but one or two hours' time. These observations were omitted until the others had been reduced and the datum areas computed. It was then decided to interpolate depths for those days when soundings were not taken. The interpolations have been made on the supposition that the change in datum areas, or the change in the bed of the stream, has been proportional to the time. Allowance has also been made for variations in stage.

Let h', h and h'' be gauge-readings on three dates;
x' and x'' scaled depths at a point on the cross-section on the first and last dates;
n = number of days between first and last dates;
and, m = number of days between first and second dates.

Then the required depth, x, at the same point on the second date has been obtained by the formula,

$$x = x' + h - h' + \frac{m}{n}(x'' - x') + \frac{m}{n}(h' - h'')$$

In this manner depths have been interpolated for 39 dates, the labor of making the interpolations probably exceeding what would have been necessary to have observed the depths originally in the field. The time occupied in sounding the section varied from forty minutes to two hours. The discharges for these dates have then been computed in the usual manner.

The results of the computation are given in the tabulation accompanying this report. The gauge-readings for days on which areas were measured or interpolated were taken directly from the observer's notes and correspond to the mean time of observations. The readings for other days have been taken from the regular gauge record at Carrollton, which is taken at 8 a. m. There are some discrepancies between the gauge-readings at this station as taken by the regular observer and as taken by the discharge party, although it is supposed that both read the standard gauge. The change in twenty-four hours has been taken from the regular record, as the discharge party did not read the gauge at regular hours and sometimes omitted reading it altogether.

Datum areas have been computed in the following manner: Datum was assumed to correspond to the gauge-reading, 13.54 feet, observed January 31, 1885, and datum width was taken as 2,562 feet. The banks were supposed to have uniform slopes below the gauge-reading 8 feet, between 8 and 12 feet, and between 12 and 13.54 feet. Width at a stage of 12 feet was taken as 2,375 feet, and at 8 feet as 2,250 feet.

Between 12 and 13.54 feet on the gauge—

$$\text{Datum area} = (13.54 - h)\,\frac{2562 + w}{2} + \text{water area.}$$

Between 8 and 12 feet on the gauge—

$$\text{Datum area} = (13.54 - 12)\,\frac{2562 + 2375}{2} + (12 - h)\,\frac{(2375 + w)}{2} + \text{water area.}$$

$$= 3801 + (12 - h)\,\frac{2375 + w}{2} + \text{water area.}$$

Below 8 feet on the gauge—

$$\text{Datum area} = 3801 + (12 - 4)\,\frac{2375 + 2250}{2} + (8 - h)\,\frac{2250 + w}{2} + \text{water area.}$$

$$= 13051 + (8 - h)\,\frac{2250 + w}{2} + \text{water area.}$$

In the above formulæ h represents gauge-reading and w observed width.

Mean depth has been obtained by dividing the observed area by the observed widt Mean datum depth has been obtained by dividing the datum area by the datum widt Maximum depth has been taken directly from the soundings. Scour or fill has be obtained by taking differences of datum areas. Scour has been indicated by the po tive sign.

Mean velocity has been obtained by dividing the discharge by the area. As h been noticed at the other stations already reduced the variations in mean velociti come mainly from the measured velocities, and are relatively much greater than th variations in areas. As the area and mean velocity are the factors making up th discharge, and as the variations in area are small in comparison with those in me velocity, it is evident that areas could be interpolated at this station and still gi valuable results for discharge since the more variable factor had been observe There are some variations in areas however which are quite large, the change in me datum depth from February 10 to February 12 being 4.1 feet, or about one-fourth t total oscillation of stage at Carrollton. Had the area on February 11 been observe instead of interpolated, valuable information might have been gained as to this lar change in area. The plotted cross-sections show that the change extended throug out the width of the cross-section.

The direction of the wind is indicated by dividing the horizon into 12 parts a numbering the parts the same as the hours on a clock dial, XII being up-stream a indicating a down-stream wind. The force of the wind is not well defined and given in the tabulation as contained in the notes.

Slope observations consisted of a number of readings of gauges 1 mile apa In a sketch in the notes the gauges are shown on each side of the river, but on o one day has slope been observed on both sides of the river, and on only two days h it been indicated on which bank slope was observed. The slope has been given the tabulation as if taken on the left bank on the theory that it would have be easier to observe on that bank, and hence more likely to have been taken there. T observations usually consisted of five readings of the upper and lower gauge, but t manner of reading them is not given. The slope is given in the table in terms of t seventh place of decimals.

Accompanying this report is a plate, on which are plotted the mean velocitie areas, and discharges as abscissas to gauge heights as ordinates, the scale for ea system of co-ordinates being given in the plate. Interpolated areas have not be plotted. The gauge-readings and datum areas have been plotted in chronologic order. The section as sounded February 2, 1885, is also shown on the plate.

The gauge-readings, areas, datum areas, mean velocities, and discharges have al been plotted in chronological order on another plate for purposes of study and inspec tion. The scale is too large to admit of reproduction of the plate.

Very respectfully, your obedient servant,

L. L. WHEELER,
In charge Computing Division.

Capt. THOMAS TURTLE,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

Discharge observations at Carrollton, La.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.							
			Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1884.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet.	Feet.	Sq. ft.	Feet.	Cu. ft.	
Oct. 8	1.70	+0.20	150,545	177,699	67.6	69.4	123.6	2,227	....	1.965	295,766	VII, fresh.
9	2.08	+0.40	152,695	179,010	68.4	69.9	120.0	2,231	+1,311	2.095	319,953	V, light.
10	2.92	+0.50	152,300	176,730	68.3	69.0	122.9	2,230	−2,280	2.318	353,026	IV, light.
11	3.11	+0.30	155,196	179,203	69.6	69.9	124.6	2,231	+2,473	2.182	338,671	VI, light.
12	3.50	+0.30	....	....	......	......	......	......	....	......	....	
13	3.60	+0.10	156,992	179,899	70.4	70.2	121.6	2,230	+ 696	2.415	379,151	VII, light.
14	3.69	+0.10	158,039	180,749	70.8	70.6	123.4	2,232	+ 850	2.478	391,702	VII, fresh.
15	3.55	−0.15	....	....	......	......	......	......	....	......	....	
16	3.62	+0.15	155,495	178,357	69.7	69.6	123.1	2,230	−2,392	2.573	400,030	V, fresh.
17	3.24	−0.40	155,223	178,936	69.6	69.8	125.5	2,230	+ 579	2.566	398,360	XII, light.
18	3.03	−0.20	153,812	177,993	69.0	69.5	120.6	2,229	− 943	2.546	391,583	XI, light.
19	2.90	−0.20	....	....	......	......	......	......	....	......	....	
20	3.09	+0.10	154,845	178,894	69.4	69.8	123.0	2,230	+ 901	2.427	375,855	Calm.
21	3.09	+0.10	157,535	181,586	70.6	70.9	126.1	2,231	+2,692	2.572	405,127	VIII, light.
22	3.16	+0.20	156,457	....	......	......	......	2,231	....	2.510	392,774	VII, light.
23	3.30	......	....	....	......	......	......	......	....	......	....	
24	3.55	+0.30	154,856	177,882	69.3	69.4	123.2	2,233	−3,704	2.558	396,187	XII, light.
25	3.29	−0.20	154,404	178,010	69.2	69.5	121.8	2,232	+ 128	2,676	413,180	VIII, slight.
26	3.60	+0.20	....	....	......	......	......	......	....	......	....	
27	3.78	+0.30	156,319	178,829	70.0	69.8	124.0	2,233	+ 819	2.398	374,912	Calm.
28	3.50	−0.40	....	....	......	......	......	......	....	......	....	
29	3.50	......	156,102	179,237	69.9	70.0	123.2	2,232	+ 408	2.244	350,272	VIII, light.
30	3.11	−0.40	155,143	....	......	......	......	2,232	....	2.327	361,015	VII, light.
31	2.83	−0.20	153,938	178,575	69.0	69.7	121.8	2,232	− 662	2.281	351,133	VII, fresh.
Nov. 1	2.62	−0.30	151,196	176,304	67.7	68.8	120.2	2,232	−2,271	2.335	353,058	XII, light.
2	2.40	−0.20	....	....	......	......	......	......	....	......	....	
3	2.43	......	152,415	177,940	68.4	69.5	120.0	2,229	+1,636	2.261	344,565	VII, light.
4	2.39	−0.10	152,542	178,159	68.4	69.5	117.7	2,230	+ 219	2.268	346,029	V, light.
5	2.55	+0.10	153,368	....	......	......	......	2,230	....	2.181	334,488	VI, light.
6	2.47	+0.40	153,720	179,158	68.9	69.9	121.6	2,230	+ 999	2.266	348,313	Do.
7	2.55	−0.10	153,926	179,185	69.0	69.9	122.3	2,230	+ 27	2.435	374,863	VII, light.
8	2.46	+0.10	153,134	....	......	......	......	2,230	....	2.184	334,449	Do.
9	2.40	−0.40	....	....	......	......	......	......	....	......	....	
10	2.22	−0.10	151,447	177,439	68.0	69.3	122.8	2,228	−1,746	2.120	321,115	IX, light
11	2.19	−0.10	151,915	....	......	......	......	2,228	....	2.184	331,727	VI, light.
12	2.19	......	152,408	....	......	......	......	2,228	....	1.919	292,489	VII, light.
13	2.07	−0.10	152,565	178,896	68.4	69.8	121.9	2,229	+1,457	2.028	309,472	IV, light.
14	1.96	−0.10	151,200	177,772	67.9	69.4	121.4	2,227	−1,124	1.988	300,575	V, light.
15	1.77	−0.30	152,306	179,301	68.4	70.0	120.5	2,227	+1,529	1.981	301,670	VII, light.
16	1.30	−0.40	....	....	......	......	......	......	....	......	....	
17	1.42	−0.10	151,354	179,128	68.0	69.9	122.2	2,225	− 173	1.982	300,001	X, light.
18	1.46	+0.20	153,653	181,337	69.1	70.8	122.0	2,225	+2,209	1.933	297,051	VII, light.
19	1.26	−0.10	151,754	179,886	68.2	70.2	122.0	2,225	−1,451	1.946	295,250	VII, fresh.
20	1.17	......	151,351	....	......	......	......	2,225	....	1.890	285,999	VIII, light.
21	1.06	−0.10	150,874	179,436	68.0	70.0	121.9	2,220	− 450	1.795	270,826	X, light.
22	1.50	+0.30	....	....	......	......	......	......	....	......	....	
23	1.50	......	....	....	......	......	......	......	....	......	....	
24	1.44	−0.20	152,067	179,799	68.3	70.2	122.1	2,226	+ 363	1,767	268,682	VIII, strong.
25	1.20	−0.10	....	....	......	......	......	......	....	......	....	
26	1.35	+0.10	153,082	181,009	68.8	70.7	120.3	2,224	+1,210	1.653	253,029	VII, fresh.
27	1.38	......	153,240	....	......	......	......	2,224	....	1.612	246,968	IX, light.
28	1.40	+0.10	....	....	......	......	......	......	....	......	....	
29	0.80	−0.50	152,250	181,393	68.6	70.8	121.9	2,220	+ 384	1.831	278,770	XI, fresh.
30	0.55	−0.35	....	....	......	......	......	......	....	......	....	
Dec. 1	0.39	−0.15	150,086	180,145	67.6	70.3	116.9	2,221	−1,248	1.712	256,922	
2	0.34	−0.10	149,099	179,270	67.2	70.0	119.4	2,220	− 875	1.796	267,822	I, fresh.
3	0.54	+0.10	149,808	179,532	67.5	70.1	118.4	2,220	+ 262	1.755	262,916	XI, light.
4	0.50	+0.10	....	....	......	......	......	......	....	......	....	
5	1.16	−0.20	152,363	181,222	68.7	70.8	119.7	2,226	+1,690	1.784	272,753	X, fresh.
6	1.81	+0.30	154,934	181,774	69.6	71.0	121.9	2,227	+ 552	2.015	312,128	IX, slight.
7	1.50	+0.90	....	....	......	......	......	......	....	......	....	
8	1.35	−0.10	152,779	180,709	68.7	70.5	119.4	2,225	−1,065	1.885	287,943	Calm.
9	1.30	+0.05	152,592	....	......	......	......	2,235	....	1.874	285,976	VI, light.
10	1.50	+0.05	....	....	......	......	......	......	....	......	....	
11	1.40	−0.10	....	....	......	......	......	......	....	......	....	
12	1.45	+0.10	152,700	180,403	68.7	70.4	123.2	2,224	− 306	1.870	285,606	V, slight.
13	1.12	−0.40	152,063	....	......	......	......	2,223	....	1.737	264,130	VII, strong.
14	1.10	0.00	....	....	......	......	......	......	....	......	....	
15	1.03	0.00	151,982	180,625	68.3	70.5	119.6	2,224	+ 222	1.703	258,873	VI, light.
16	0.69	−0.30	156,217	179,617	67.6	70.1	121.0	2,223	−1,008	1.950	292,877	X, strong.
17	0.65	−0.10	149,616	....	......	......	......	2,223	....	1.734	259,412	III, light.

Discharge observations at Carrollton, La.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.
			Area.		Depth.							
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.					
1884.	Feet.	Feet	Sq. Ft.	Sq. Ft.	Feet.	Feet.	Feet.	Feet.	Sq. Ft.	Feet.	Cu. ft.	
Dec. 18	0.70	0.00	......	......	......	......	......	......	......	......	......	
19	0.56	—0.20	148,437	178,127	66.8	69.5	120.0	2,223	—1,490	1.801	267,338	IV, light.
20	0.50	0.00	......	......	......	......	......	......	......	......	......	
21	1.10	+0.60	......	......	......	......	......	......	......	......	......	
22	2.20	+0.40	152,692	178,932	68.6	69.8	121.5	2,229	+ 805	2.244	343,021	I, light.
23	2.47	+1.00	151,674	180,115	69.3	70.3	123.2	2,231	+1,183	2.109	326,140	VI, light.
24	2.70	+0.20	154,598	179,524	69.3	70.1	122.3	2,231	— 591	2.216	342,625	VII, fresh.
25	2.88	+0.20	155,577	......	......	......	......	2,231	......	2.297	357,330	VII, light.
26	2.89	0.00	156,452	180,952	70.1	70.6	122.8	2,231	+1,428	2.473	386,902	
27	3.20	+0.30	......	......	......	......	......	......	......	......	......	
28	3.40	+0.20	......	......	......	......	......	......	......	......	......	
29	3.79	+0.05	159,575	......	......	......	......	2,234	......	2.737	436,828	Very strong.
30	3.87	+0.10	159,799	182,109	71.5	71.1	123.5	2,234	+1,157	......	......	Strong.
31	4.11	+0.50	159,464	......	......	......	......	2,235	......	2.821	449,884	V, strong.
1885.												
Jan. 1	4.50	+0.45	......	......	......	......	......	......	......	......	......	
2	4.87	+0.50	159,880	179,958	71.4	70.2	126.4	2,240	—2,151	3.022	483,178	VII, light.
3	5.26	0.00	161,110	......	......	......	......	2,241	......	3.030	488,222	Do.
4	6.85	+1.85	......	......	......	......	......	......	......	......	......	
5	7.95	+1.10	......	......	......	......	......	......	......	......	......	
6	8.00	+0.05	......	......	......	......	......	......	......	......	......	
7	8.43	+0.85	169,231	181,357	73.9	70.8	129.9	2,289	+1,899	4.274	723,261	V, light.
8	9.14	+0.65	170,816	......	......	......	......	2,292	......	4.311	736,896	
9	9.87	+1.00	172,680	181,467	74.8	70.8	130.2	2,307	+ 110	4.651	803,092	Calm.
10	10.38	+0.40	173,463	......	......	......	......	2,308	......	4.767	826,925	Do.
11	11.00	+0.60	......	......	......	......	......	......	......	......	......	
12	11.19	+0.45	174,619	180,344	73.5	70.4	135.5	2,375	—1,123	4.925	860,001	Do
13	11.50	+0.05	......	......	......	......	......	......	......	......	......	
14	11.67	+0.25	177,289	181,874	74.6	71.0	135.3	2,375	+1,530	5.083	901,073	
15	11.93	+1.05	177,643	......	......	......	......	2,375	......	4.984	885,404	
16	12.42	+0.05	178,505	......	......	......	......	2,375	......	5.202	928,512	
17	12.15	+0.15	177,458	180,889	74.7	70.6	133.1	2,375	— 985	5.228	927,678	
18	12.55	—0.45	......	......	......	......	......	......	......	......	......	
19	12.47	—0.05	176,933	179,628	71.5	70.1	136.8	2,475	—1,261	......	......	
20	12.78	+0.10	180,045	......	......	......	......	2,475	......	5.396	971,539	V, strong.
21	12.95	+0.05	181,756	183,242	71.7	71.5	135.4	2,476	+3,614	5.363	974,809	Strong.
22	13.55	—0.10	......	......	......	......	......	......	......	......	......	
23	13.55	0.00	......	......	......	......	......	......	......	......	......	
24	13.15	—0.40	......	......	......	......	......	......	......	......	......	
25	13.20	+0.05	......	......	......	......	......	......	......	......	......	
26	13.22	+0.05	179,432	180,247	70.8	70.3	135.8	2,532	—3,115	5.572	999,808	VII, light.
27	13.29	+0.05	179,643	......	......	......	......	2,532	......	5.727	1,028,833	X, strong.
28	13.40	+0.04	180,208	180,561	72.6	70.5	136.6	2,482	+ 434	5.786	1,042,608	VII, light.
29	13.44	+0.06	178,758	......	......	......	......	2,545	......	5.827	1,041,714	IX, fresh.
30	13.44	0.00	177,238	......	......	......	......	2,545	......	5.887	1,043,383	VIII, fresh.
31	13.54	+0.03	176,554	176,554	68.9	68.9	143.5	2,562	—4,007	5.748	1,014,887	Calm.

Discharge observations at Carrollton, La.—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Slope. Sin. of inclination.	
			Area.		Depth.									
	Reading.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.						R. bank.	L. bank.
1885.	Ft.	Feet.	Sq. ft.	Sq. ft.	Ft.	Ft.	Ft.	Ft.	Sq. ft.	Ft.	Cu. ft.			
Feb. 1	13.46	+0.03												
2	13.54	+0.01	178,777	178,777	70.2	69.8	143.1	2,548	+ 2,223	6.163	1,101,671	Calm		
3	13.59	—0.01	178,655					2,549		5.862	1,047,271	II, light		
4	13.42	—0.04												
5	13.42	0.00												
6	13.45	0.00	177,737					2,532		5.723	1,017,242	Calm		
7	13.37	0.00	177,656	178,089	70.2	69.5	147.2	2,532	— 688	5.854	1,039,936	XII, strong		312
8	13.44	+0.02												
9	13.47	+0.03												
10	13.24	—0.0[illegible]	174,052	174,814	69.1	68.2	131.0	2,517	— 3,275	5.687	989,860	VI, light		
11	13.01	—0.03	178,225					2,517		5.610	999,786	VIII, light	337	350
12	13.15	0.0[illegible]	184,203	185,192	73.3	72.3	141.5	2,512	+10,378	5.371	989,422	VII, light		
13	12.97	0.0[illegible]	183,733					2,511		5.334	980,086	VI, strong	384	
14	13.00	—0.0[illegible]	183,610	184,977	73.4	72.2	140.5	2,500	— 215	5.207	956,076	V, light		356
15	12.38	—1.02												
16	12.56	—0.03	184,502	186,968	74.7	73.0	134.2	2,470	+ 1,991	5.038	929,595	V, light		417
17	12.32	—0.03												
18	12.28	0.00	185,072	188,236	75.2	73.5	131.2	2,460	+ 1,268	4.871	901,524	VII, fresh		
19	12.24	—0.02	181,545					2,460		4.869	883,999	Calm		458
20	12.12	0.00	177,936	181,495	72.6	70.8	133.0	2,451	— 6,741	4.781	850,662	VIII, light		441
21	12.09	—0.04	177,789					2,450		4.572	812,829	IX, strong		379
22	12.00	—0.26												
23	12.05	—0.22	177,528	181,257	72.6	70.7	127.0	2,444	— 238	4.507	816,183	VIII, light		440
24	12.00	+0.22												455
25	11.92	—0.22	179,658	183,652	73.7	71.7	133.6	2,439	+ 2,395	4.714	846,842	VI, slight		455
26	11.81	—0.02	178,018	182,271	74.7	71.1	132.8	2,383	— 1,381	4.562	812,161	V, light		477
27	11.74	—0.43	178,205					2,383		4.539	808,796	Calm		455
28	11.41	+0.02	177,819	183,021	74.9	71.5	131.3	2,373	+ 750	4.607	819,219	II, fresh		466
Mar. 1	11.33	—0.02												
2	11.15	—0.13	171,262	177,078	72.3	67.1	136.4	2,368	— 5,943	4.340	743,347	V, light		468
3	10.83	—0.30	169,768					2,366		4.226	717,520	I, light		407
4	10.71	—0.12	169,729					2,365		4.021	682,522	VII, light		
5	10.30	—0.13	168,937					2,363		3.939	665,494	IV, light		
6	9.92	—0.40	168,257	176,979	71.4	69.1	132.4	2,357	— 99	4.047	680,911	VII, light		
7	9.53	—0.45	166,925					2,352		3.909	652,477	III, light		386
8	9.10	—0.40												
9	8.86	—0.25	164,168	175,364	70.3	68.4	127.1	2,335	— 1,615	3.887	638,154	VIII, fresh		394
10	8.70	—0.12	163,671	175,237	70.2	68.4	126.3	2,331	— 127	3.797	621,445	Calm		201
11	8.68	—0.03	163,042					2,330		3.835	625,187	X, fresh		337
12	8.69	0.00	162,563	174,152	70.2	68.0	127.0	2,331	— 1,085					379
13	8.72	+0.03	162,134					2,331		3.791	614,578	Calm		312
14	8.81	+0.12	161,800	173,105	69.4	67.6	127.0	2,330	— 1,047	3.810	616,389	Calm		368
15	9.10	+0.25												
16	9.45	+0.25	163,598					2,335		3.965	648,655	Calm		373
17	9.56	+0.22	164,048	173,598	70.2	67.8	128.6	2,337	+ 493	4.053	664,921	Calm		381
18	9.74	+0.23	166,082	175,295	71.1	68.4	130.2	2,335	+ 1,607	4.019	667,494	VI, slight		
19	9.92	+0.15	165,329					2,336		4.138	684,087	III, light		358
20	10.16	+0.25	164,618	172,754	70.4	67.4	130.7	2,337	— 2,451	4.103	675,413	III, light		349
21	10.60	+0.25	165,709							4.284	709,905	IX, fresh		
22	10.70	+0.25												
23	10.72	0.00	166,471	173,308	70.2	67.7	134.4	2,370	+ 554	4.358	725,498	VII, light		
24	10.90	0.00	166,153	172,568	69.9	67.4	130.7	2,377	— 740	4.452	739,772	IX, fresh		352
25	11.00	+0.28	166,104	172,281	69.9	67.2	129.7	2,377	— 287	4.450	739,078	X, light		345
26	11.20	+0.22												318
27	11.45	+0.25												341
28	11.50	+0.07	169,617	174,606	71.3	68.1	131.5	2,378	+ 2,325					345
29	11.52	+0.00												
30	11.52	+0.00												
31	11.40	—0.12												

A 5.

Elevations of high waters.

Locality.	Distance.	1858.	1862.	1867.	1874.	1876.	1880.	1882.	1883.	1884.	1886.	1887.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo	......	341.40	342.71	341.81	338.21	337.22	335.44	342.71	343.01	342.63	341.86	339.42
Columbus	21.2	329.77	330.92	330.44	......	......	326.31	331.93	332.42	332.22	332.02	330.13
Salmon's Landing	33.6	......	......	325.56	......	......	322.13	326.90	327.23	327.15	326.30	......
Morrison's Landing	68.9	......	315.24	......	......	......	310.74	317.29	317.54	317.54	316.44	313.81
Cottonwood Point	123.3	288.68	288.68	288.09	......	......	286.00	288.18	288.47	287.96	287.71	....
Fulton	175.4	......	......	......	......	......	262.72	265.22	264.84	264.28	263.97	263.15
Memphis	230.3	238.13	238.43	238.82	237.97	238.06	237.38	239.12	238.72	238.12	238.77	239.37
Mboons Landing	275.8	......	....	......	......	....	217.58	221.28	221.68	220.36	220.45	......
Helena	306.5	206.58	208.37	207.79	207.77	206.82	205.66	209.17	208.88	208.98	210.08	206.28
Delta	314.4	208.86	......	....	203.34	203.10	201.89	204.39	203.97	......	......	......
White River	394.4	......	......	175.53	175.33	175.43	275.28	177.13	176.57	176.47	176.93	176.48
Riverton	399.6	172.34	173.32	171.49	172.45	172.78	172.34	174.48	174.06	173.98	......	174.17
Arkansas City	438.3	....	......	......	......	......	161.52	163.45	163.57	162.71	163.11	163.00
Greenville	478.5	151.00	......	147.92	148.92	149.28	148.41	149.72	148.40	149.10	149.20	148.93
Lake Providence	542.3	......	130.50	128.93	127.00	127.58	126.86	127.94	126.10	128.03	127.54	127.62
Vicksburg	599.2	112.94	117.14	115.06	111.74	110.94	109.19	114.79	109.84	115.04	110.19	110.74
Saint Joseph	647.7	......	......	......	......	......	94.04	96.87	93.87	97.65	......	....
Natches	700.4	85.08	82.01	84.76	82.44	80.69	79.95	84.43	80.84	84.24	80.50	81.03
Red River Landing	765.3	......	......	70.18	70.85	69.26	67.90	72.35	68.86	70.96	65.79	66.85
Baton Rouge	833.3	54.57	56.17	......	56.21	53.46	53.26	56.02	55.15	56.27	52.17	53.56
Donaldsonville	885.4	......	48.85	......	48.29	....	45.28	47.27	47.27	47.33	......	......
Carrollton	957.0	36.01	36.81	......	36.61	33.61	35.16	35.86	36.31	36.51	34.71	35.41

High-water marks of 1886 and 1887.

1886.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation (Cairo datum).	Fall between high-water marks.	Distance between high-water marks.	Slope per mile.	Date of high water.
		Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Cairo, Ill.*	...	......	341.86	......	......	......	April 19.
Columbus, Ky	L.	21.2	332.02	......	......	......	April 19.
Mean	...	21.2	......	9.90	21.2	.471	
Belmont, Mo.*	R.	21.2	331.72	......	......	......	April 19.
Salmon's Landing	L.	33.6	326.30	5.57	12.4	.449	April 19.
Hickman	L.	36.0	325.21	1.09	2.4	.454	April 19.
James Bayou	R.	44.5	322.10	3.11	8.5	.365	April 21.
Lester's Landing	L.	53.7	320.00	2.10	9.2	.228	April 17.
Morrison's*	R.	69.0	316.44	3.56	15.3	.232	April 20.
Point Pleasant	R.	79.5	310.83	5.61	10.5	.534	April 20.
Gayoso	R.	105.7	296.87	13.96	26.2	.532	April 20.
Cottonwood Point	R.	123.3	287.71	9.16	17.6	.520	April 21.
Ward's Landing	R.	148.2	276.59	10.12	24.9	.406	April 19.
Fulton, Tenn.*	L.	175.4	263.97	12.62	27.2	.463	April 22.
Randolph, Tenn	L.	182.6	260.90	3.07	7.2	.426	April 22.
Pecan Point, Ark	R.	196.0	253.55	6.35	13.4	.473	April 22.
Thomas Landing, Tenn	L.	201.2	252.34	1.21	5.2	.232	April 22.
Memphis, Tenn.*	L.	230.3	238.77	13.57	29.1	.466	April 23.
Star Landing, Miss. (1 mile above)	L.	257.2	226.41	12.36	26.9	.459	April 30.
Commerce Landing, Miss	L.	269.8	222.43	3.98	12.6	.315	April 30.
Mboon's (½ mile above)	L.	275.6	220.45	1.98	5.8	.341	April 29.
Austin, Miss	L.	288.0	215.93	4.52	12.4	.364	April 29.
Cartwright's (behind Trotter's)	L.	304.0	211.91	4.02	16.0	.251	
Helena, Ark.*	R.	306.5	210.08	1.83	2.5	.732	April 30.
Opposite Glendale	R.	306.8	209.86	.12	.3	......	
Glendale, Miss	L.	306.8	209.73	.13	......	......	
Below Grant's Pass	L.	313.0	207.01	2.72	6.2	.438	April 27.
Friar's Point	L.	319.0	204.08	2.93	6.0	.488	April 26.
Miller's Point	L.	325.0	200.79	3.29	6.0	.548	April 29.
Saint Louis Landing, Ark	R.	349.5	190.60	10.19	24.5	.415	May 2.
Sunflower Landing, Miss	L.	352.7	189.27	1.33	3.2	.415	May 2.
Anderson's Landing, Miss	L.	359.0	187.15	2.12	6.3	.336	April 30.
Australia, Miss	L.	370.0	184.70	2.45	11.0	.222	May 3.

*United States gauge.

High-water marks of 1886 *and* 1887—Continued.

1886.

Locality of high-water marks.	Bank.	Distance from Cairo.	Elevation (Cairo datum).	Fall between high-water marks.	Distance between high-water marks.	Slope per mile.	Date of high water.
		Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
…nia, Ark	R.	373.8	183.16	1.54	3.3	.467	May 5.
…cordia, Miss	L.	378.0	182.14	1.02	4.7	.217	May 4.
…te River, Ark.*	R.	393.2	176.93	5.21	15.2	.342	May 4.
…et's, Miss	L.	414.7	171.56	4.37	21.5	.203	April 25.
…ish Point, Miss	L.	423.2	168.92	2.64	8.5	.310	May 4.
…ansas City, Ark.*	R.	438.3	163.11	5.81	15.1	.384	May 5.
…rellyn Place	R.	463.5	154.82	8.29	25.2	.329	May 6.
…nville, Miss.*	L.	478.5	149.20	5.62	15.0	.374	May 6.
…field Point, Miss	L.	483.5	147.45	1.75	5.0	.350	May 4.
… Providence*	R.	542.3	127.54	19.91	58.8	.338	May 7.
…sburg, Miss.*	L.	599.3	110.19	17.35	57.0	.304	May 7–9.
…t Pleasant, La	R.	622.2	100.38	9.81	22.9	.428	May 18–19.
…gent, La	R.	679.3	88.27	12.10	57.1	.212	May 6.
…hez, Miss.*	L.	700.4	80.59	7.68	21.1	.364	May 9–11.
…k Hawk Landing	R.	747.2	71.54	9.05	46.8	.193	
…River Landing*	R.	765.3	65.79	4.75	18.1	.263	May 31.
…n Rouge*	L.	833.3	52.17	13.62	68.0	.200	May 31 to June 2.
…gton Plantation	L.	837.3	51.92	.25	4.0	.062	
…ouri Plantation	R.	838.7	51.37	.55	1.4	.392	June 1.
…e's Store	R.	855.2	49.16	2.21	16.5	.134	May 30.
…nt Airy Plantation	L.	915.8	39.88	9.28	60.6	.153	June 6.
…ollton, La.*	L.	957.0	34.71	5.17	31.2	.165	May 31.

1887.

…, Ill.*	……	……	339.42	……	……	……	Mar. 9.
…ont, Mo.*	R.	21.3	330.13	9.29	21.3	.436	Mar. 10.
… Bayou, Mo	R.	44.5	320.35	9.78	23.2	.422	Mar. 12.
…ison's Landing, Mo.*	R.	69.0	313.81	6.54	24.5	.267	Mar. 12.
…t Pleasant, Mo	R.	79.5	309.05	4.76	10.5	.453	Mar. 11.
…so, Mo	R.	105.7	295.68	13.37	26.2	.510	Mar. 12.
…l's, Ark	R.	148.2	275.84	19.84	42.5	.467	Mar. 11.
…n, Tenn.*	L.	175.4	263.15	12.69	27.2	.467	Mar. 12.
…olph, Tenn	L.	182.6	260.28	2.87	7.2	.399	Mar. 14.
…phis, Tenn.*	L.	230.0	239.27	21.01	47.4	.443	Mar. 10.
…na, Ark.*	R.	306.5	208.28	30.99	76.5	.405	Mar. 21.
…r's Point, Miss	L.	319.0	202.78	5.50	12.5	.440	Mar. 21.
…t Louis Landing, Ark	R.	349.5	189.77	13.01	30.5	.426	Mar. 17.
…ralia, Miss	L.	370.0	184.08	5.69	20.5	.278	Mar. 23.
…th of White River*	R.	393.2	176.48	7.60	23.2	.328	Mar. 24.
…rton, Miss	L.	399.0	174.17	2.31	5.8	.399	Mar. 23.
…ett's	L.	414.7	171.23	2.94	15.7	.187	Mar. 22.
…sh Point, Miss	L.	423.2	168.88	2.35	8.5	.277	Mar. 25.
…nsas City, Ark.*	R.	438.3	163.00	5.88	15.1	.390	Mar. 26.
… Landing, Ark	R.	467.4	153.77	9.23	29.1	.317	Mar. 25.
…nville, Miss.*	L.	478.5	148.93	4.84	11.1	.436	Mar. 21.
… Providence, La.*	R.	542.3	127.62	21.31	63.8	.334	Mar. 26.
…sburg, Miss.*	L.	599.3	110.74	16.88	57.0	.296	Mar. 26.
…t Pleasant, La	R.	622.2	102.92	7.82	22.9	.341	Mar. 29.
…p's Landing, La	R.	659.3	89.32	13.60	37.1	.367	Apr. 2.
…ess Grove, Miss.†	L.	669.5	(?) 88.65	(?) .67	10.2	……	Mar. 29.
…hez, Miss.*	L.	700.4	81.08	7.62	30.9	.202	Mar. 31.
…k Hawk Landing, La.‡	R.	(?) 747.2	72.04	8.99	(?) 46.8	……	Apr. 10.
…River Landing, La.*	R.	765.3	66.85	5.19	18.1	.218	Apr. 8.
…n Rouge, La.*	L.	833.5	53.56	13.29	68.2	.195	Apr. 9.
…e's Store, La	R.	854.7	50.16	3.40	21.2	.160	Apr. 9.
…nt Airy Plantation, La	L.	915.8	40.46	9.70	61.1	.159	Apr. 5.
…ollton, La.*	L.	957.0	35.41	5.05	41.2	.122	Apr. 6.

*United States gauge. † Reject. ‡ Location in doubt; reject.

APPENDIX B.

REPORT OF LIEUTENANT JAMES L. LUSK, CORPS OF ENGINEERS, SECRETARY OF COM- MITTEE ON CONSTRUCTION.

THE MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE COMMITTEE ON CONSTRUCTION,
2653 *Olive Street, Saint Louis, Mo., June* 30, 1887.

SIR: I have the honor to report as follows upon the work of this office during th fiscal year ending June 30, 1887:

On August 9, 1886, I relieved Capt. Thomas Turtle, Corps of Engineers, of hi duties as secretary of the committee on construction. At that time the gener service fleet was laid up at Chester, where a large portion of it has remained duri the year. At the meeting of the Commission in September last the care of the surve fleet was transferred to this office. That fleet has also remained at Chester dur the year.

As soon as practicable after the passing of the act of August 5, 1886, the steam and barges were put in good condition. Thirty-six of the barges were docked, thoroughly repaired. The remaining nineteen were repaired as far as their co tion demanded at the time. Part of this work was kindly done by Captain Le with the force employed by him at Plum Point, under authority received from t president of the Commission.

On September 27, 1886, requisition was received from Captain Leach for 3, cubic yards of stone for use in Memphis Harbor. At that time none of the steam or barges were fit for work and the state of navigation was bad, the Ohio River b ing so low as to shut off any supply of stone from that quarter. The entire st business, also, was badly disorganized. The penitentiary at Chester, previously most regular and convenient source of supply, declined to furnish any stone, w elsewhere between Saint Louis and Cairo there was no adequate quantity ready loading. As a result, the stone had to be obtained from Grafton, Ill., where it furnished by Mr. George Blackman, under informal contract, at 56 cents per cu yard, loaded upon the barges. The extreme low water rendered it impossible for *Minnetonka* to handle more than seven barges in a tow, and even then much soundi of crossings was necessary, and some double-tripping. The tows were also serio impeded by high winds and fogs, and the cost of delivering them brought the to price of the stone to about $1.70 per cubic yard. The whole quantity sent to Me phis was 3,689 cubic yards, delivered in two tows.

In bringing back empty barges from Plum Point, No. 193 was badly snagged Island 40, but was saved and repaired.

After completing her work of towing stone the *Minnetonka*, while engaged in t ing the *Mississippi* and the last of the repaired barges to winter quarters at Ches ran upon a wreck near the head of Arsenal Island, on December 2, and was resc with some difficulty. For fear that her hull might have been damaged, and to fa itate resetting her chains, which had been broken, she was docked, but was found have sustained comparatively little injury.

On December 24, the *Minnetonka* and *Mississippi*, with some barges lately off t ways, finally went into winter quarter at Chester. The extreme low water whi prevailed all winter made the care of the fleet expensive, the ice gorging both bel and above it, but no damage was done. The experience of last winter, combin with that of the winter of 1885-'86, seems to indicate that no safer ice-harbor th Chester is to be found between Saint Louis and Cairo.

The *Minnetonka* was employed during the year in towing the *Mississippi* and p of the barges from Chester to Saint Louis for repairs, in moving stone from Saint L to Memphis, as described above, in bringing back empty barges from Plum Po to Chester, and returning repaired plant from Saint Louis to Chester.

The *Emma Etheridge* was borrowed from the Missouri River Commission and e ployed in towing some barges from Chester to Saint Louis for repairs, at a ti when the *Mississippi* and *Minnetonka* were both out of commission, and also in ke ing the fleet free from running ice during part of December, 1886.

The *Mississippi* ran only from Saint Louis to Chester, after undergoing repairs the former point.

On February 24, 1887, contract was entered into with James Mack, of Cincinna Ohio, for constructing eleven coal barges, at $1,975 each. The work was somewh delayed by high water, but much more by the financial embarrassment of the co tractor, who, in May, effected a transfer of the contract to one of the bondsme This was afterwards revoked, and a power of attorney then executed, authorizi the same bondsman to receive any payments to become due under the contract. Th question whether, under the circumstances, any of the barges could be accepted,

ny payments made, was forwarded for decision about the end of the fiscal year. At that time five of the barges had been nearly completed.

The mechanical draughtsman was employed in making a survey of the tow-boat *Mississippi*, and in nearly completing working drawings of that vessel and her machinery; in making drawings of the machinery of the *Minnetonka;* in completing the main drawings of the *Emma Etheridge;* in preparing drawings and specifications for coal barges for the general service, and for a steam-launch for the first district, to replace the *H. L. Abbot;* and in drawing up specifications for repairs to machinery of the tow-boats.

The amount available on July 1, 1886, was $20,816.89, and an allotment of $214,000 was made by the Commission at its meeting in September, 1886. There was expended during the year, $63,549.02; transferred to mouth of Red River, $15,000, and to Memphis Harbor, $500, leaving as an available balance on June 30, 1887, $155,767.87.

The expenditures for the general service, incident to moving stone, are apportioned among the districts according to the work done for each; the general expenses of the office, and those for repairs to and care of plant, are divided equally among the first, second, and third districts.

I present herewith a directory of the Commission, with its officers, and districts under improvement, statement of value of plant June 30, 1887, detailed statement of expenditures by the general service, detailed financial statement of all expenditures from July 1, 1886, to June 30, 1887, and a general statement of appropriations and expenditures from March 3, 1881, to June 30, 1887.

THE MISSISSIPPI RIVER COMMISSION.

Col. and Bvt. Maj. Gen. Quincy A. Gillmore, Corps of Engineers, president, 33 West Houston street, New York.

Lieut. Col. and Bvt. Brig. Gen. Cyrus B. Comstock, Corps of Engineers, 33 West Houston street, New York.

Lieut. Col. Charles R. Suter, Corps of Engineers, 1415 Washington avenue, Saint Louis.

Henry Mitchell, civil engineer, Office United States Coast and Geodetic Survey, Washington, D. C.

B. M. Harrod, civil engineer, Cotton Exchange Building, New Orleans.

Hon. Robert S. Taylor, post-office box 1648, Fort Wayne, Ind.

S. W. Ferguson, civil engineer, Greenville, Miss.

Capt. Smith S. Leach, Corps of Engineers, secretary, 2828 Washington avenue, Saint Louis.

THE COMMITTEE ON CONSTRUCTION.

Messrs. Gillmore, Comstock, Suter, and Harrod.

First Lieut. James L. Lusk, Corps of Engineers, secretary and assistant, 2653 Olive street, Saint Louis.

Officers of Corps of Engineers in charge of districts.

Districts.	Name and address of officer in charge.	Extent of district.
		Miles.
Illinois River to Ohio River	Maj. A. M. Miller, custom-house, Saint Louis	245
First district—Ohio River to foot of Island No. 40 (Plum Point Reach).	Capt. Smith S. Leach, custom-house, Cairo, Ill., and Elmot, Ark.	220
Second district—Foot of Island No. 40 to White River (Memphis Reach).	Capt. Smith S. Leach, 280 Front street, Memphis, Tenn.	180
Third district—White River to Warrenton, Miss. (Lake Providence Reach).	Capt. William T. Rossell, Memphis, Tenn., and Wilson's Point, La.	220
Fourth district—Warrenton to Head of Passes.	Capt. Dan C. Kingman, 3 South Rampart street, New Orleans.	484

Approximate value of plant belonging to the United States and used in the work of improving the Mississippi River (general service).

Class of property.	Approximate value, June 30, 1887.
Steam-boat *Mississippi*	$50,000
Steam-boat *Minnetonka*	33,000
1 pump-boat	500
1 store-boat	100
2 sounding-boats	25
28 barges (flush deck)	28,000
27 barges (low deck)	32,400
Office furniture	475
Total	144,500

Expenditures on account of appropriation for improving Mississippi River (no limit) from allotment for general service, from July 1, 1886, to June 30, 1887.

Repairs to general service plant	$31,348.43
Repairs to Commission survey plant	574.58
Special repairs to steamer *Minnetonka*	2,472.38
Running expenses, steamer *Mississippi*	1,202.71
Running expenses, steamer *Minnetonka* and *Etheridge*	3,779.35
Fuel for steamers and pump-boat	2,041.78
Office rent, salaries, and contingencies	8,852.71
Administration and inspection	1,116.81
Care of general service plant	11,160.38
Care of Commission survey plant	1,000.00
Total	63,549.02

The above expenditures were apportioned as follows:

To first district	$20,542.65
To second district	22,463.72
To third district	20,542.65

Financial statement, July 1, 1886, to June 30, 1887.

General service:		
Available July 1, 1886	$20,816.89	
Allotment, act August 5, 1886	214,000.00	
		$234,816.89
Transferred to mouth of Red River	15,000.00	
Transferred to Memphis Harbor	500.00	
Expenditures apportioned to June 30	60,058.07	
Expenditures unapportioned	3,490.95	
		79,049.02
Balance in Treasury	143,526.87	
Balance in hand	12,241.00	
		155,767.87
Des Moines Rapids to Illinois River:*		
Available July 1, 1886	27,829.06	
Received from sale of fuel	22.50	
		27,851.56
Expended		27,851.56
Illinois River to Ohio River and protection of the easterly bank of the Mississippi near Cairo:*		
Available July 1, 1886		41,309.65
Expended, Illinois River to Ohio River	$24,576.90	
Expended, Cairo	8,143.60	
		32,720.50
Balance in hand		8,589.15

* Includes only funds under act of July 5, 1884.

New Madrid Reach:		
(Allotment expended before July 1, 1886.)		
Plum Point Reach:		
Available July 1, 1886	$1,527.02	
Drawn from Treasury for general service	20,542.65	
Allotment, act August 5, 1886	377,250.00	
Deposit for overpayment	6.00	
		$399,325.67
Expended		73,018.42
Balance in Treasury	317,256.00	
Balance in hand	9,051.25	
		326,307.25
Saint Francis Front (first district):		
(Allotment expended before July 1, 1886.)		
Hickman, Ky.:		
Allotment, act August 5, 1886 (none of which has been expended)		18,750.00
Columbus, Ky.:		
Allotment, act August 5, 1886 (none of which has been expended)		18,750.00
Memphis Harbor and Reach:		
Available July 1, 1886	$5,802.11	
Allotment, act August 5, 1886	60,000.00	
Drawn from Treasury for general service	22,463.72	
		88,265.83
Expended		27,401.27
Balance in Treasury	60,000.00	
Balance in hand	864.56	
		60,864.56
Memphis Harbor:		
Available July 1, 1886	1,231.53	
Allotment, act August 5, 1886	56,250.00	
Transferred from general service	500.00	
Deposit for overpayment	.30	
		57,981.83
Expended		26,969.42
Balance in Treasury	21,250.00	
Balance in hand	9,762.41	
		31,012.41
Saint Francis Front (second district):		
(Allotment expended before July 1, 1886.)		
Survey of Helena Reach:		
(Allotment expended before July 1, 1886.)		
Lake Providence Reach:		
Available July 1, 1886	5,996.85	
Transferred from levees, Tensas Front	1,500.00	
Transferred from Delta Point	1,000.00	
Drawn from Treasury for general service	20,542.65	
Allotment, act August 5, 1886	270,000.00	
Deposit for overpayment	.20	
		299,039.70
Expended		68,344.31
Balance in Treasury	226,500.00	
Balance in hand	4,195.39	
		230,695.39
Vicksburg Harbor (survey):		
Allotment, act August 5, 1886		2,500.00
Expended		2,500.00
Vicksburg Harbor (dredging):		
(Allotment expended before July 1, 1886.)		
Vicksburg Harbor (Delta Point):		
Available July 1, 1886		60.59
Expended		60.59

Delta Point:		
Allotment, act August 5, 1886	$5,000.00	
Transferred to Lake Providence Reach	1,000.00	
		$4,000.00
Expended		3,968.10
Balance in hand		31.90
Survey of unleveed fronts (third district):		
(Allotment expended before July 1, 1886.)		
Choctaw Bend survey:		
(Allotment expended before July 1, 1886.)		
Repair of floating plant (third district):		
Allotment, act August 5, 1886		30,000.00
Expended		30,000.00
Greenville, Miss.:		
Allotment, act August 5, 1886 (none of which has been drawn or expended)		37,500.00
New Orleans Harbor:		
Available July 1, 1886	$2,007.65	
Allotment, act August 5, 1886	75,000.00	
		77,007.65
Expended		39,535.25
Balance in Treasury	32,500.00	
Balance in hand	4,972.40	
		37,472.40
Mouth of Red River:		
Available July 1, 1886	4,364.43	
Transferred from general service	15,000.00	
		19,364.43
Expended		19,013.60
Balance in hand		350.83
Red and Atchafalaya Rivers:		
Allotment, act August 5, 1886		187,500.00
Expended		27,128.84
Balance in Treasury	$157,500.00	
Balance in hand	2,871.16	
		160,371.16
Natchez and Vidalia:		
Available July 1, 1886		1,000.65
Expended		175.00
Balance in hand		825.65
Observations at Carrollton:		
(Allotment expended before July 1, 1886.)		
Survey of unleveed fronts (fourth district):		
(Allotment expended before July 1, 1886.)		
Survey of Cubitt's Gap:		
(Allotment expended before July 1, 1886.)		
Levees (first district):		
Plum Point:		
Allotment, act August 5, 1886		100,000.00
Expended		86,853.66
Balance in hand		13,146.34

Levees (second district):		
(*Yazoo Front.*—Allotment expended before July 1, 1886.)		
(*Long Lake.*—Allotment expended before July 1, 1886.)		
Yazoo-Miss-Delta:		
Allotment, act August 5, 1886		$100,000.00
Expended		99,918.00
Balance in hand		82.00
Levees (third district):		
Tensas Front:		
Available July 1, 1886		2,000.00
Transferred to Lake Providence Reach	$1,500.00	
Expended	456.12	
		1,956.12
Balance in hand		43.88
Tensas Front (Ark.):		
Allotment, act August 5, 1886		94,920.86
Expended		30,657.67
Balance in Treasury	$43,920.86	
Balance in hand	20,342.33	
		64,263.19
Yazoo Front:		
(Allotment expended before July 1, 1886.)		
Yazoo Front—Ben Lomond Loop:		
Allotment, act August 5, 1886		12,000.00
Expended		10,783.23
Balance in hand		1,216.77
Yazoo Front—Hughes Break:		
Paid by Treasury draft		6,849.69
Opossum Fork:		
Allotment, act August 5, 1886		38,500.00
Expended		28,109.99
Balance in hand		10,390.01
Protection of levees:		
Allotment, act August 5, 1886		18,000.00
Expended		13,077.02
Balance in Treasury	$4,000.00	
Balance in hand	922.98	
		4,922.98
Levees (fourth district):		
Atchafalaya Front:		
Available July 1, 1886	511.35	
Allotment, act August 5, 1886	40,000.00	
		40,511.35
Expended		40,511.35
Tensas Front:		
Available July 1, 1886	$1,413.72	
Allotment, act August 5, 1886	11,100.00	
		12,513.72
Expended		10,613.66
Balance in hand		1,900.06

Protection of levees:		
Allotment, act August 5, 1886		$7,000.00
Expended		503.82
Balance in hand		6,496.18
Total available July 1, 1886 (levees)	$3,925.07	
Allotments, act August 5, 1886	421,520.86	
Hughes Break	6,849.69	
		432,295.62
Transferred to Lake Providence Reach	1,500.00	
Expended	328,334.21	
		329,834.21
Balance in Treasury	47,920.86	
Balance in hand	54,540.55	
		102,461.41

Statement of funds available for improving Mississippi River, from March 3, 1881, to June 30, 1887.

Act of March 3, 1881		$1,000,000.00
Act of August 2, 1882		4,123,000.00
Act of January 19, 1884		1,000,000.00
Act of July 5, 1884, less $5,000 transferred to snag-boat service		2,065,000.00
Act of August 5, 1886, less $5,942.60 for expenses Office Chief of Engineers		1,994,057.40
Total specific appropriations		10,182,057.40
Balances from former appropriations applied to works below Cairo under act of August 2, 1882, less $123.42, reverted to Treasury	$272,504.96	
Same, for works above Cairo under act of July 5, 1884	22,632.53	
Total balances		295,137.49
Received from sales and loss of property		660.41
Total available		10,477,855.30
Expended to June 30, 1887		9,074,918.47
Available July 1, 1887	$1,189,749.98	
Unallotted in United States Treasury	213,186.85	
		1,402,936.83

Detailed statement of funds applied to improving the Mississippi River, under the Mississippi River Commission, from March 3, 1881, to June 30, 1887.

Districts.	From appropriations.	From balances.	From sales.	Total available.	Expended.	Balances in Treasury.	Balances in hand.	Total balances.
Des Moines Rapids to Illinois River	$195, 000. 00	$12, 663. 38	$145. 14	$207, 808. 52	$207, 808. 52			
Illinois River to Ohio River	470, 000. 00	9, 969. 15	126. 60	480, 095. 75	480, 095. 75			
Protection near Cairo	50, 000. 00			50, 000. 00	41, 410. 85		$8, 580. 15	$8, 589. 15
	520, 000. 00	9, 969. 15	126. 60	530, 095. 75	521. 506. 60		8, 589. 15	8, 589. 15
Survey Saint Francis Front	4, 873. 11			4, 873. 11	4, 873. 11			
New Madrid Reach	210, 361. 91		2. 83	210, 364. 74	210, 364. 74			
Plum Point Reach	2, 808, 260. 69		105. 70	2, 808, 366. 39	2, 482, 059. 14	$317, 256.00	9, 051. 25	326, 307. 25
Hickman, Ky	18, 750. 00			18, 750. 00		18, 750. 00		18, 750. 00
Columbus, Ky	18, 750. 00			18, 750. 00		18, 750. 00		18, 750. 00
Levees: Plum Point	100, 000. 00			100, 000. 00	86, 853. 66		13, 146. 34	13, 146. 34
Totals first district	3, 160, 995. 71		108. 53	3, 161, 104. 24	2, 784, 150. 65	354, 756. 00	22, 197. 59	376, 953. 59
Survey Saint Francis Front	4, 000. 90			4, 000. 00	4, 000. 00			
Survey Helena Reach	8, 000. 00			8, 000. 00	8, 000. 00			
Levees: Long Lake	15, 000. 00			15, 000. 00	15, 000. 00			
Yazoo Front	80, 950. 00			80, 950. 00	80, 950. 00			
Yazoo, Mississippi Delta	100, 000. 00			100, 000. 00	99, 918. 00		82. 00	82. 00
Memphis Harbor	256, 750. 00		22. 80	256, 772. 80	225, 760. 39	21, 250. 00	9, 762. 41	31, 012. 41
Memphis Harbor and Reach	600, 050. 26		27. 14	600, 077. 40	539, 212. 84	60, 000. 00	864. 56	60, 864. 56
Totals second district	1, 064, 750. 26		49. 94	1, 064, 800. 20	972, 841. 23	81, 250. 00	10, 708. 97	91, 958. 97
Survey Vicksburg Harbor	2, 500. 00			2, 500. 00	2, 500. 00			
Survey unleveed Fronts	1, 000. 00			1, 000. 00	1, 000. 00			
Survey Choctaw Reach	2, 679. 86			2, 679. 86	2, 679. 86			
Levees: Opossum Fork	63, 500. 00			63, 500. 00	53, 109. 99		10, 390. 01	10, 390. 01
Yazoo Front	364, 878. 95			364, 878. 95	364, 878. 95			
Yazoo Front (Ben Lomond)	12, 000. 00			12, 000. 00	10, 783. 23		1, 216. 77	1, 216. 77
Yazoo Front (Hughes' Break)	6, 849. 69			6, 849. 69	6, 849. 69			
Tensas Front	411, 640. 00			411, 640 00	411, 596. 12		43. 88	43. 88
Tensas Front (Arkansas)	94, 920. 86			94, 920. 86	30, 657. 67	43, 920. 86	20, 342. 33	64, 263. 19
Protection of levees	18, 000. 00			18, 000. 00	13, 077. 02	4, 000. 00	922. 98	4, 922. 98
Greenville, Miss	37, 500. 00			37, 500. 00		37, 500. 00		37, 500. 00
Repairs to floating plant	30, 000. 00			30, 000. 00	30, 000. 00			
Vicksburg Harbor: Dredging	61, 812 12			61, 812. 12	61, 812. 12			
Delta Point	93, 736. 46	25, 770. 13		119, 506. 59	119, 506. 59			
Delta Point	4, 000. 00			4, 000. 00	3, 968. 10		31. 90	31. 90
Lake Providence Reach	2, 587, 823. 46		218. 95	2, 588, 042. 41	2, 357, 347. 02	226, 500. 00	4, 195. 39	230, 695. 39
Totals third district	3, 792, 841. 40	25, 770. 13	218. 95	3, 818, 830. 48	3, 469, 766. 36	311, 920. 86	37, 143. 26	349, 064. 12

Detailed statement of funds applied to improving the Mississippi River, under the Mississippi River Commission, etc.—Continued.

Districts.	From appropriations.	From balances.	From sales.	Total available.	Expended.	Balances in Treasury.	Balances in hand.	Total balances.
Survey Cubitt's Gap	137.14			137.14	137.14			
Survey unleveed fronts	1,000.00			1,000.00	1,000.00			
Observations at Carrollton	3,000.00			3,000.00	3,000.00			
Bonnet Carre Crevasse	15,000.00			15,000.00	15,000.00			
Natchez and Vidalia harbors		8,252.04		8,252.04	7,426.39		825.65	825.65
New Orleans Harbor	82,823.47	147,670.39		230,493.86	193,021.46	32,500.00	4,972.40	37,472.40
Mouth of Red River	38,405.00	90,812.40		129,217.40	128,866.57		350.83	350.83
Red and Atchafalaya rivers	187,500.00			187,500.00	27,128.84	157,500.00	2,871.16	160,371.16
Levees: Tensas Front	564,370.00			564,370.00	562,469.94		1,900.06	1,900.06
Atchafalaya Front	176,800.00			176,800.00	176,800.00			
Protection of levees	7,000.00			7,000.00	503.82		6,496.18	6,496.18
Totals fourth district	1,076,035.61	246,734.83		1,322,770.44	1,115,354.16	190,000.00	17,416.28	207,416.28
General service	159,247.57		11.25	159,258.82	3,490.95	143,526.87	12,241.00	155,767.87
Unallotted in United States Treasury	213,186.85			213,186.85		213,186.85		213,186.85
Grand totals	10,182,057.40	295,137.49	660.41	10,477,855.30	9,074,918.47	1,294,640.58	108,296.25	1,402,936.83

Respectfully submitted.

JAS. L. LUSK,
First Lieutenant of Engineers, Secretary Committee on Construction.

Col. Q. A. GILLMORE,
President Mississippi River Commission.

APPENDIX C.

REPORT OF CAPTAIN SMITH S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 25, 1887.

SIR: I have the honor to submit the following report upon the work of improving Mississippi River, first district, for the fiscal year ending June 30, 1887.

From the beginning of the year until October nothing was done except the care of the floating and other property.

Early in August the passage of a river and harbor bill gave hope of a resumption of operations, and to provide for this, as well as to restore the plant to a proper condition, from which shortage of funds for two years had caused it to greatly deteriorate, a thorough repairing was undertaken.

Prior to the general allotment of the appropriation by the Commission preliminary estimates for this purpose were sent in and were approved by the Secretary of War. The amount allotted to the first and second districts was $20,000. This sum was expended almost entirely in making the floating property sea-worthy and weather-proof.

Experience having shown that, in view of the first cost, cost and frequency of repairs, and danger from fire and unexpected leaks, the canvas roofs heretofore used are not suitable for the purpose, a change to tin was made for all roofs except those of steam-boats and two shingle-roofed quarter-boats. The work amounted to 899 squares. It was done by contract, at $7.60 per square. Some deductions for assistance rendered and board of mechanics reduced the actual cash payment to the contractor to $6,619.40 The new roofs have given entire satisfaction. Aside from this, the expenditures were principally for labor of calkers and carpenters, and for lumber and oakum devoted to calking and repairing of gunwales, rakes, and decks. A small force of mechanics was employed in overhauling machinery and other work preparatory to putting pile-drivers in commission.

At a meeting of the Commission in September an allotment of $377,250 was made for continuing the work on Plum Point Reach. Notification of the approval of this allotment was received on the 22d of November, and a project for its expenditure was at once submitted.

Later new projects in greater detail were called for, and as much time had already been lost, and the working season was nearing its close, a partial project covering work of most urgency was hastily prepared and returned at once (December 8). This project contemplated repairs to the Plum Point system of dikes by closing breaks, and to the Bullerton No. 2 dike by a re-enforcement throughout its length. The estimate was $40,000.

Notification of the approval of this project and estimate and authority to begin work were received January 11, and the necessary preparations were at once begun. Before materials could be collected the spring rise set in, and nothing further could be done until April, when work on the Plum Point system was begun with a small force and prosecuted, with interruptions from high and low water, until completed.

Dike No. 5 had two breaks, with the intervening portion much damaged, and was rebuilt from the inner side of the inner gap to the outer end of the dike, a total length of 800 feet.

Dike No. 6 had also two breaks, but farther apart. The ends adjoining were good and the breaks were closed at small cost. All the work was of the standard three-row dike. No tipped or foot mats were used. The tipped mats of the original dike had broken down and disappeared, and it was not thought advisable to make the new work less permeable than the old. In all cases the old foot-mats were found in place and sufficient penetrations through them were procured, thus securing the new work against undermining without the cost of new foot-mats. The outer end of each dike was strengthened by three clumps of three large cypress piles each, driven as deep as possible, and strongly fastened to each other and to the dike. In the immediate vicinity of the new work its favorable results are already apparent. A longer interval of time and higher prevailing stages of water will be requisite to develop the effect of these repairs in increasing the efficiency of the Plum Point system.

At almost the very hour that the first tow of cypress piles designed for the re-enforcement of Bullerton No. 2 dike, under this same project and estimate, arrived at the head of the work, that dike broke, and its repair became an entirely new question. After the decline of the flood the dike was found in such condition as to make the cost of repairing it far greater than its value when done. Since the close of the year a new dike, below the old one, has been proposed and approved. It is hoped to complete it without exceeding the original allotment.

The total expenditures from this allotment have been $9,722.60, of which $7,460.77 was applied to the Plum Point repairs. The difference, $2,261.83, represents the value of materials and supplies on hand available for the new dike proposed.

On December 30, 1886, a project for the expenditure of the remainder of the Pl Point allotment was forwarded to the president of the Commission. This proj provided for the extension of the Fletcher revetment, to cost $180,000, and the co pletion of the closure of Elmot and Island 30 chutes by dikes near their lo ends, the two estimated to cost $130,000. This project was approved by the Comm sion and forwarded to the Secretary of War. It was referred by the Secretary Congress, raising the question as to whether the proposed revetment traversed t limitation placed by Congress upon that class of work. The project and all the c respondence are published in Ex. Doc. No. 88, Senate, Forty-ninth Congress, seco session. No further action had been taken up to the close of the fiscal year, b since that time the amounts named have been withdrawn and reallotted to levees.

The allotment of $100,000 for levees on the Plum Point Reach was approved by t Secretary of War, and notification of that fact reached me on the 9th November. T work was at once advertised, and the bids were opened on the 25th:

The following bids were received:

No.	Names of bidders.		Price per cubic yard for earth-work.	Price p acre for f ing timb
			Cents.	
1	Messrs. McTighe, McKee & Harvey		21	$4.
2	J. J. Cooney		21½	40.
3	Thomas F. Duffin and Henry Duffin	Sections 1 to 5	24	40.
		Sections 6 to 12	21	40.
		Ashport	25	....

The award was made to the lowest bidders, Messrs. J. S. McTighe & Co., of Memphis. They began work on December 2, and pushed it with most commendable energy. The conduct of the gentlemen composing the firm, individually as well as collectively, left no room for doubt of their determination to fully and cheerfully meet every obligation, expressed or implied, which their contract imposed upon them. Previous experience led me to expect interruption of such work by high water about February 15, and that date was fixed in the contract for the completion of the work. The work was seriously interfered with on the 16th, and on the 21st was brought to a stop. By this time the work was practically completed, so far as the restriction of overflow was concerned. But for two weeks of freezing weather in January, during which time frost penetrated the ground to a depth of 9 inches—a very unusual thing for this latitude—the work would have been completed within the contract time, except the sodding, which I had postponed, in the interest of the United States, to a more favorable season. Observations during the overflow convinced me of the desirability of extending the work at the upper end a short distance beyond the terminus first selected.

An extension of the contract to the time when the sodding could be safely done was necessary, and finding sufficient funds remaining, I took occasion during the extension to order the additional work done. The levee as completed consists of two parts, joining near Ashport in a very obtuse angle. The new levee extending down the river is 55,000 feet in length, and extends to the upper end of the Plum Point dikes. The flank line, or "old levee," is 8,800 feet long, and joins a piece of fairly good levee extending 2 miles farther. Both are built with 3 and 3 to 1 slopes, and crowns of 6, 8, and 10 feet, the one nearest the height being used. The specifications were based on those previously used for the United States levees.

During the high water and while the levee was soft the only trouble experienced was from wave and rain wash and sloughing. Nothing alarming occurred at any time. Sacks and bagging were supplied, and a small patrol and repair force was kept employed. The latter, in addition to insuring the safety of the levee, accomplished much in the direction of redressing it for sodding.

The effect of this levee in restricting the escape of water from the river has been most gratifying. The sum allotted was less than half the estimated cost of a levee to completely stop the overflow; but its application to this line has had the effect of stopping all but the small amount of 20,000 cubic feet per second. This fact was determined by careful and repeated observations during the high water, and has resulted in a determination not to build the rest of the line, at least until other openings on the reach, where more good can be done with the same money, are closed.

The effects of the increased volume of water upon the channel have been marked, and in the aggregate beneficial. The caving of banks in the channels through which the volume of flow was considerably increased was noticeably accelerated. The channel at Island 30 crossing, where the increased volume was first concentrated in a single stream, was deepened by several feet.

The total channel area in the stretch of river where concentration has been effected was considerably increased by the lowering of 8 to 10 feet of the crests of three middle bars. This example is as free from extraneous complications as can reasonably be hoped for, and it can scarcely be doubted that the prevention of overflow by this levee and the enlargement of channel in the vicinity, immediately following, stand to each other in the relation of cause and effect.

The slope observations indicate a greater fall of water-surface during the flood of 1887, restrained by the levee, than during that of 1886 not so restrained. In other words, the enlargement of channel caused by the levee was accompanied by a lower flood level, as would naturally be expected. A balance of $13,146.34 remains for this work, from which the right of way is yet to be paid. It will be used in mowing weeds and such repairs as become necessary, and if a surplus remains it will be applied to extending the line at the upper end.

The loss of channel works during the fiscal year has been comparatively small, and all from causes which can be avoided in future work. Two cross-dikes have been broken by the pressure of drift, the break in each case having been made possible by the rotting of the piles. Bullerton No. 2 was broken by the pressure of drift above it on the 9th of February, the gauge reading 28 feet, while the same dike had withstood the year before the pressure of the same mass of drift at a stage 5 feet higher, and had in addition been subjected to the impact of a large field of drift which came down from a broken dike above. The impairment of strength by another year's decay was the sole cause of its breaking. The current through the chute increased about 50 per cent. immediately after the break, but did not reach a point where any scour could occur. The bottom in the neighborhood of the dike is full of logs imbedded in the sand, and no loss of deposits previously secured has taken place or may be expected. Discharge observations made fifteen days after the break showed the discharge through the chute to be but 6.7 per cent. of the total volume of the river.

Osceola No. 1 was a comparatively small dike and one of the oldest. It broke on March 2 by the drift moving over it, the river being at nearly its highest stage. In this case, as in the other, none of the deposits already secured have been or will be lost, but remain to attest the past usefulness of the lost works. These two dikes aggregate 2,200 feet in length, and are estimated to have cost $83,500.

The only loss of revetment has been at the middle section in Fletcher's Bend. But little caving has taken place between these sections during the year, the unprotected portions of the bank having receded until they were shielded by the projecting revetments. The entire destructive effort of the river has for the past year been directed against the middle section of this revetment. The bottom has scoured to a great depth in front of it, thus throwing a violent current close to the bank, and eddies above and below have attacked it in the rear. The result has been that at the cost of a short length of revetment about 3 miles of bank have been held on a nearly stable line, and this stability of bank has played an important part in the stability of channel below, which is at once the cause and the proof of improved navigation. The loss during the year has been about 500 feet, estimated to have cost $12,500, and this sum represents the total loss of this class of work on this reach during the year.

Aside from the cutting down of the middle bars above noted as a probable effect of the levee, there have been no noteworthy changes in the depths or directions of the channels. On the Plum Point crossing, which is the only one under thorough control of the works, no depths less than 10 feet have at any time been found. This depth was only met with on two or three occasions, and for a day or two at a time, and was the result of temporary obstructions, which the current soon removed. The prevailing depths at extreme low water have been 12 and 13 feet, and at average low water 15 feet. The other shoal on the reach, known as the Island 30 crossing, carried from one to three feet less than the one just described, reaching minima of 8.5 and 9 feet. As before noted, however, as soon as the effect of the levee was felt this channel scoured out and has since been practically equal in depth with the Plum Point crossing.

The Island 30 crossing depends for its permanence of location and adequate depth almost wholly upon the maintenance of a fixed bank line in Fletcher's Bend, immediately above. If another year's neglect of the Fletcher's revetment allows that bend to resume its caving, obstructed navigation may be expected at Island 30.

There are submitted herewith financial statements and general balance sheet for the allotments in the first district, a list of civilian engineers, and a table of the value of plant.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

General Q. A. GILLMORE,
President Mississippi River Commission.

Appropriation for improving Mississippi River, first district.

FINANCIAL STATEMENT.

Balance on hand June 30, 1886, as per last report, including estimated liabilities		$1,540.5
Amounts received since (act of August 5, 1886):		
On account Plum Point Reach	$377,250.00	
On account levees Plum Point Reach	100,000.00	
On account Hickman, Ky	18,750.00	
On account Columbus, Ky	18,750.00	
		514,750.
Total		516,290.
Expended from July 1, 1886, to June 30, 1887:		
On account Plum Point Reach	$52,489.31	
On account levees Plum Point Reach	86,853.66	
		139,342.9
Balance June 30, 1887		376,947.5

SMITH S. LEACH,
Captain of Engineers.

Appropriation for improving Mississippi River, first district.—General balance sheet.

PLUM POINT REACH.

1886. June 30	To balance, including estimated liabilities	$1,540.56	1887. June 30	By amount expended from July 1, 1886, to June 30, 1887	$52,489.31
Nov. 18	To allotment from appropriation, act of August 5, 1886	377,250.00	June 30	By balance	326,301.25
		378,790.56			378,790.56

LEVEES, PLUM POINT REACH.

1886. Nov. 18	To allotment from appropriation, act of August 5, 1886	$100,000.00	1887. June 30	By amount expended to date	$86,853.66
			June 30	By balance	13,146.34
		100,000.00			100,000.00

HICKMAN, KY.

1886. Aug. 5	To amount appropriated act of August 5, 1886	$18,750.00	1887. June 30	By balance	$18,750.00

COLUMBUS, KY.

1886. Aug. 5	To amount appropriated act of August 5, 1886	$18,750.00	1887. June 30	By balance	$18,750.00

SMITH S. LEACH,
Captain of Engineers.

List of civilian engineers employed on work of river and harbor improvements in charge of Capt. Smith S. Leach, Corps of Engineers, from November 1, 1886, *to June* 30, 1887, *both inclusive, under the river and harbor appropriation act approved August* 5, 1886.

Name and place of residence.	Time employed. M.	Time employed. d.	Compensation per month.	Where employed.	Work on which employed.
J. A. Ockerson, Saint Louis, Mo.	8		$200	Saint Louis, Mo ...	Survey of Mississippi River.
L. L. Wheeler, Saint Louis, Mo.	8		175	... do	Do.
Edward Moliter, Saint Louis, Mo.	4		175	....do	Do.
C. W. Clark, Saint Louis, Mo..	8		125	....do	Survey of Mississippi River and inspecting water-gauges Mississippi River.
Elvas Tully, Saint Louis, Mo..	8		125	....do	Survey of Mississippi River.
John Ewens, Saint Louis, Mo..	6	11	125	... do	Do.
L. C. Jones, Saint Louis, Mo...	7		110	....do	Do.
E. H. Twining, New York, N.Y.	8		150 / 175	New York, N. Y....	Do.
W. M. Rees, Memphis, Tenn...	2 / 6		100 / 150	Memphis, Tenn.....	Improving Mississippi River, Memphis Harbor and reach, Plum Point Reach, and Yazoo levees.
Aug. J. Nolty, Sans Souci, Ark.	8		125	Plum Point Reach..	Improv'g Mississippi River, Plum Point Reach.
Chas. W. Stewart, Illinois......	6		100	....do	Surveys.
F. A. Fisher, Memphis, Tenn..		8	120	Memphis, Tenn.....	Levee inspector, Plum Point levees.
S. Elliott Moore, Memphis, Tenn.	6 / 1	12½	140 / 145	Plum Point Reach..	Do.
Geo. Selman, Tennessee	1	8	140	In the field..........	Levee inspector.
J. M. Kloster, Memphis, Tenn.	4	5	140	....do	Do.
E. T. Washburn, Memphis, Tenn.	3 / 2	12	75 / 100	....do	Do.
Jas. S. Martin, Memphis, Tenn.	3		60	....do	Do.
H. M. Marshall, Memphis, Tenn.	3 / 2	12	55 / 100	....do	Do.

SMITH S. LEACH,
Captain of Engineers.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River.—First district.

Class of property.	No.	Approximate value, June 30, 1887.
Steamer *P. Kirns*	1	$5,372
Steamer *Itasca*	1	5,780
Steamer *Abbott* (damaged by fire)	1	1,476
Launch *Titania*	1	720
Pile-drivers	37	84,608
Quarter boats	14	19,173
Mattress boats	10	18,112
Graders	2	25,206
Derrick boats	2	3,909
Barges	50	33,043
Machine-shop boat	1	3,613
Whitehall boats	7	156
Skiffs	60	358
Tools and appliances	......	7,000
Office furniture	......	80
Surveying instruments	......	200
Total	......	208,806

SMITH S. LEACH,
Captain of Engineers.

APPENDIX D.

REPORT OF CAPTAIN SMITH S. LEACH, CORPS OF ENGINEERS, UPON OPERATIONS IN THE SECOND DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 25, 1887.

SIR: I have the honor to submit the following report upon the work of "Improving Mississippi River," second district, for the fiscal year ending June 30, 1887:

The only work done in this district under the appropriation for improving Mississippi River was the continuation of the revetment of the Memphis Harbor front. This work was provided for by a special item of $57,250 in the act of August 5, 1886. It was simply the continuation of a project already formulated, approved, and partly executed under former appropriations, and comprising in general terms the protection of the bank by continuous revetment from a point above Wolf River to the lower end of the paved levee at Beale street, a total length of over 7,000 feet. The part remaining to be done was from Jefferson to Beale streets, comprising the whole of the paved levee, a length of 3,000 feet.

Later changes in the regimen of the river had transferred the maximum strain from the upper to the lower end of this portion, and it appearing from the estimates that the entire work could not be done for the money available, it was decided to begin at the lower end and work up-stream as far as possible. Improved methods of construction, an unusually favorable working season, and probably a wholesome provision for contingencies in the former estimates, have made it possible to complete the work with the present funds. All but about 600 feet was covered during the working season last fall, and an ample balance remains to complete that portion at the next low water.

No changes of importance were made in the methods of construction. The first mattress was 285 feet wide and 700 feet long, the second was 265, and the third and fourth 250 feet wide, all having net lengths of about 500 feet. Upon the completion of this work a full report with statements of cost will be made.

For more than two years past the caving of the bluff below the paved levee has caused great apprehension. During the latter part of the last fiscal year the situation became very critical. Several valuable manufacturing sites threatened to cave into the river. One wing of an elevator did fall in, and part of the storage sheds of an oil-mill had to be torn down to prevent their going the same way. An ice company lost several inclines.

The break of the bank had approached within a few feet of railroad tracks in Tennessee street, which bring four roads into the city. Behind Tennessee street were oil-mills, an ice factory, and a brewery, and behind these again some of the choice residence property of the city on Shelby street.

Finding that the plan of the Government operations in this locality did not promise any work on this front, the parties interested applied to me for an opinion as to the possibility of preventing this caving. I informed them that I believed it could be done, and outlined the plan I would propose, being a system of submerged spurs of brush-cribs ballasted with stone, resting on large floor mats, extending to high-water mark. Being requested to put the plan on paper, I did so, and with it as a basis an organized effort was made to raise the necessary funds. My estimate was $55,000 for five spurs, protecting 2,200 feet. The volume of the subscription was placed at $60,000. Of this sum $40,000 was subscribed by the four railroads and the balance by private parties. All these preliminaries were based upon the supposition that arrangements could be made to use such of the Government plant then lying idle as might be needed for the work.

Application was made to the Secretary of War, resulting in permission to use the necessary plant and any materials which might be on hand. This latter provision made the United States a contributor to the work in a small sum, and is the reason why this description appears in my official report. The loan of the plant was under the condition that it should remain in my possession and be worked by me, which devolved upon me the immediate conduct of the work. As the same thing had already been proposed by the citizens' committee, it was acceptable to them.

Work began the latter part of July and the five spurs were completed by the end of December. They were subjected to a severe strain by the prolonged and very high flood which occurred this year. They were not damaged in the least, and have prevented any further loss of ground. They have caused considerable deposits, but less than I had hoped. An endeavor will be made to increase the deposits by putting in two or more short spurs between the main ones. Having succeeded in stopping the ravages of the river, I am now ambitious to restore to these people a portion of the ground which they have lost. A considerable balance of funds remains, and I propose to apply it as indicated.

The very small force employed during the suspension of active operations and the pressure of other work have prevented me from presenting with this report a full description of the work and a statement of its cost in detail. I do not feel that I can give this work precedence in the office over strictly official matters, but will use the first comparative leisure to prepare this information, which will be, in my judgment, of importance in connection with the general problem of river control.

A loss of about 500 feet at the lower end of the Hopefield revetment is the sum total of losses of work in this district during the fiscal year. This loss is entirely due to caving working up from below, and would not have occurred had not the work been left exposed for two years in an unfinished condition. The amount of revetment in place at the beginning of the year and its value were—

Hopefield Bend, 8,500 feet, at $20	$170,000
Memphis Harbor, 4,000 feet, at $25	100,000
Total	270,000

Of this there was lost, as above stated, 500 feet, worth $10,000, or a trifle over one-third of 1 per cent. per annum. The remainder is to all appearances as good as ever. Had money been available to extend this work there would be no loss to report.

Hopefield Point has continued to cave, though less rapidly than formerly. It has receded about 1,500 feet since December, 1885. This throws the current further down on the Memphis front and gradually increases the area of slackwater in the upper harbor.

Notification of the approval of the allotment of $100,000 for levees in the Yazoo-Mississippi Delta district was received November 13, and the work was advertised at once. After consultation with Major Dabney, the engineer of the district, and the examination of his records and of data from other sources, it was decided to put up about 200,000 yards of earthwork from the Hushpucana Levee to the Coahoma County line at the lower end of the district, the balance to be applied at intervals along the upper portion of the line.

A proposition was received from McKee, McLaws & Co., who had contracts under the State board covering the same ground, with camps established and forces organized, to put up the latter part of the work at 21 cents a yard. In view of the reasonableness of the figure and the considerable saving of time effected, this offer was accepted and that amount withdrawn from the letting. It may be remarked that in all the work subsequently let on sealed proposals no price as low as this was obtained.

Bids for the Hushpucana work were opened December 5, and were as follows:

No.	Names of bidders.	Price of earthwork per cubic yard.	Price of felling timber per acre.	Part of work proposed for.
		Cents.		
1	Daniel T. Hartnett	21½	$50.00	Sections 15, 16, 17, and 18.
2	Michael McTighe	26	35.00	Sections 15 and 16.
3	P. F. Lamb and Arthur Donnelly	25¾	55.00	The whole line.
4	J. J. Cooney	25	50.00	Sections 18, 19, and 20.
5	Hugh Feran and M. C. Pearce	25		Section 18 (Robinsonville).
6	George Arnold and A. A. Arnold	33	50.00	Sections 15 and 16.
		30		Section 17.
		22		Section 18.
		28		Sections 19 and 20.
		26		Section 21.
		22		Sections 22 to 27, inclusive.

Awards were made as follows:

	Cents.
To D. T. Hartnett, sections 15, 16, 17, and 18, at	21½
To J. J. Cooney, sections 19 and 20, at	25
To George Arnold & Co., section 21, at	26
To George Arnold and Co., sections 22 to 27, inclusive, at	22

All work has been satisfactorily completed. The upper portion consisted entirely of enlargements so distributed as, in connection with the State work, to give all the old and insecure parts of the line ample section and a grade 3 feet above the high water of 1882, the standard of the district.

The work at the lower end consisted of a re-enforcing banquette behind the large Hushpucana Levee; a similar banquette behind another large levee, known as the "Buck's Bayou;" a loop to throw out an angle at Robinsonville, which was threatened with caving, and enlargement and repairing of portions of the line adjacent. No losses

occurred during the flood. Some high-water expenses were incurred, however, to ward off threatened danger. There is good reason to believe that had not the Hushpucana Banquette been built, that enormous dam would have been seriously damaged, if not washed away.

Financial statements and general balance sheet and table of value of plant for the second district are herewith.

For list of civilian engineers employed see table accompanying my report for first district.

Very respectfully, your obedient servant,

SMITH S. LEACH,
Captain of Engineers.

General Q. A. GILLMORE,
President Mississippi River Commission.

Appropriation for Improving Mississippi River, second district.

FINANCIAL STATEMENT.

Balance on hand June 30, 1886, as per last report, including estimated liabilities		$7,026.96
Amounts received since (act of August 5, 1886):		
On account Memphis Harbor	$56,250.00	
On account Memphis Reach	60,000.00	
On account Yazoo-Mississippi Delta levee district	100,000.00	
On account sale of fuel	6.67	
On account overpayment refunded	.30	
On account steamer *Minnetonka*, refunded from general service allotment	500.00	
		216,756.97
Total		223,783.93
Expended from July 1, 1886, to June 30, 1887:		
On account Memphis Harbor	$26,969.41	
On account Memphis Reach	4,937.55	
On account Yazoo-Mississippi Delta levee district	99,918.00	
		131,824.96
Balance June 30, 1887		91,958.97

SMITH S. LEACH,
Captain of Engineers.

Improving Mississippi River, second district—General balance sheet.

MEMPHIS HARBOR.

1886. June 30	To balance	$1,231.52	1887. June 30	By amount expended from July 1, 1886, to date	$26,969.41
Aug. 5	To amount appropriated (act of August 5, 1886)	56,250.00	June 30	By balance	31,012.41
1887. Jan. 31	To overpayment refunded	.30			
May 8	To amount refunded from general service allotment on account steamer *Minnetonka*	500.00			
		57,981.82			57,981.82

MEMPHIS HARBOR AND REACH.

1886. June 30	To balance, including estimated liabilities	$5,795.44	1887. June 30	By amount expended from July 1, 1886, to date	$4,937.55
Jan. 25	To deposit, sale of fuel	6.67	June 30	By balance	60,864.56
1887. Nov. 18	To allotment from appropriation (act of August 5, 1886)	60,000.00			
		65,802.11			65,802.11

LEVEES, YAZOO-MISSISSIPPI DELTA LEVEE DISTRICT, UPPER YAZOO.

1886. Nov. 13	To amount allotted from appropriation (act of August 5, 1886)	$100,000.00	1887. June 30	By amount expended to date	$99,918.00
			June 30	By balance	82.00
		100,000.00			$100,000.00

SMITH S. LEACH,
Captain of Engineers.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River.—Second district.

Class of property.	No.	Approximate value, June 30, 1887.
Steamer *H. M. Graham*	1	$4,176.00
Launch *Daphne*	1	1,107.00
Flat-boats	3	596.00
Mattress-boats	2	5,384.00
Machine-shop boat	1	3,974.00
Screen-boats	4	2,650.00
Quarter-boats	5	5,252.00
Barges	23	19,598.00
Skiffs	14	119.00
Pile-drivers	9	19,022.00
Coal shells	2	265.00
Tools and appliances	......	3,500.00
Office furniture	......	120.00
Surveying instruments	......	150.00
Total	......	65,913.00

SMITH S. LEACH,
Captain of Engineers.

APPENDIX E.

REPORT OF CAPTAIN WILLIAM. T. ROSSELL, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
IMPROVING MISSISSIPPI RIVER, THIRD DISTRICT,
Memphis, Tenn., July 28, 1887.

SIR: I have the honor to transmit herewith inclosed copy of my annual report for the third district, improving Mississippi River, for the fiscal year ending June 30, 1887.

Very respectfully, your obedient servant,

WM. T. ROSSELL,
Captain of Engineers.

Col. Q. A. GILLMORE,
Corps of Engineers, U. S. Army,
President Mississippi River Commission, Army Building, New York.

REPORT.

The third district, improving Mississippi River, extends from mouth of White River to Warrenton, a distance of about 220 miles, and includes Lake Providence Reach and the harbors of Vicksburg and Greenville. There is also included all work done by the United States on levees on both sides of the river.

I. Lake Providence Reach.

This reach extends from Carolina Landing, 517 miles below Cairo, to the foot Island No. 95, a distance of 35 miles. This reach, and the proposed methods of i provement, have been described in the reports of the Mississippi River Commissi for past years.

During the past fiscal year no work of construction has been done nor have any pairs to existing works been carried on. The work during the year has been co fined to care of Government property, repairs to plant and surveys.

Condition of Works.

Duncansby system of dikes.—This system is in the same condition as last year. T shore ends of cross-dikes 6, 7, and 8, still hold, and in a measure deflect the wa from Skipwith Chute, which is now closed at its upper end at 20-foot stage of wat

Cottonwood system of dikes.—During the year this system has sustained considera damage. All the longitudinal dike, from its down-stream end, has washed out as far cross-dike No. 1. About 300 feet of the outer ends of cross-dikes Nos. 2 and 3 ha also gone.

A channel has developed near and parallel to the site of the longitudinal dike, sufficient width for steam-boats, 400 to 500 feet; its depth was 15 feet, L. P. gau reading 14 feet, when in the main channel there was 17 feet. It would seem proba that, with these two channels in existence, there might be shoal water here dur low water. There is also danger that the channel, in crossing the river below, m attack and injure the Baleshed system of dikes. This would seem to indicate th if it is intended to hold these dikes, something should be done before the next hi water.

Mayersville system of dikes.—Slight damage has been done here, due to the break of the piles and also to some caving. However, Mayersville Chute has shoaled dur the year, and there seems to be no probability of any enlargement at present. T breaking down of the Cottonwood system will, I believe, relieve this bank partial

Baleshed system of dikes.—These dikes, considering the length of time they ha been built, and the short life of cottonwood piles, show very gratifying results as condition and effect. The bar formed by them extends from the mouth of Maye ville chute to the foot of Stack Island, and at the 15-foot stage no water enters eit Baleshed or Stack Island chutes. There has also been a very material fill in Balesh Chute during the year. The conditions seem favorable for this work, unless chan in the vicinity of Cottonwood introduce complications.

Stack Island system of dikes.—Some damage has been done here from breaking piles in the main cross dike from drift, but the dike is in general good conditi There has been a very considerable narrowing and shoaling of the Stack Isla Chute. The depth of water reduced to zero of the L. P. gauge was, in 1882, 61 fe 1883, 44 feet; 1884, 29 feet; 1886, 25 feet; and in July, 1887, 18 feet.

Pilcher's Point revetment.—As no repairs have been placed on this work si work of construction ceased in January, 1885, as reported in my last annu much of the revetment had disappeared, but the general line of the bank had be preserved. The last high water coming on this work in its dilapidated conditi the results were severe, as was foreseen. With the exception of 800 linear feet the upper end, the work is gone. In places the caving is from 200 to 500 feet de and extends from 5,000 feet above Pilcher's to 1,500 feet below.

Mayersville Island revetment.—This revetment has practically disappeared, and ca ing has continued during the year on the head and face of the island. A space n exists between the head of the island and the Mayersville cross dike.

CHANNEL DEPTHS.

For comparison the least depths found during the low-water seasons, 1884, 1885, and 1886, and to June 30, 1887, are given in tabulated form.

Statement showing least channel depths, Lake Providence Reach, 1884, 1885, 1886, *and* 1887.

Date.	1884.			1885.			
	L. P. gauge-readings.	Stack Island Crossing.	Ben Lomond Crossing.	L. P. gauge-readings.	Dunnoansby Crossing.	Stack Island Crossing.	Ben Lomond Crossing.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
January 10	30	....	....	29.4	....	40	39
January 20	25.4	....	....	33.6	....	46	43
January 30	25.5	....	....	34.6	....	44	42
February 10	30	....	....	31.4	....	39	38.5
February 20	36.8	....	....	27.1	....	33	33
February 28	37.7	....	....	21.2	....	24.5	26.5
March 10	38.1	....	....	18.6	....	23.5	26
March 20	38.1	....	....	27.1	....	....	....
March 30	37.8	....	....	27	....	....	....
April 10	36.6	....	....	22	....	....	....
April 20	36.8	....	....	28.1	....	....	....
April 30	36.5	....	....	32.2	....	....	....
May 10	36.5	....	....	35.5	....	....	....
May 20	35.9	....	....	29.4	....	....	....
May 30	32.5	....	....	22.9	....	....	....
June 10	24.6	....	....	25	31.5	24	33.5
June 20	23.3	....	....	24.5	31	21	29.5
June 30	25.7	....	....	28	35	22.6	29.5
July 10	21.1	....	....	24.7	31.4	20	24
July 20	19.6	....	....	22	29	17	26
July 30	15.8	....	....	15.5	20	14	18.5
August 10	15.5	18	24	14.0	19	14	21
August 20	12.6	14	12	15.6	36	15	28
August 30	8.9	10	14	12.2	30	15	29
September 10	9.1	14	17	13.4	32	16	30
September 20	6.6	17	11	18	35	19	25
September 30	5.8	15	11	15.5	30	22	20
October 10	14.8	24.5	15	9	22	14	15
October 20	13.7	26	24	7.1	18	14	13
October 30	12	24.5	22.5	8	18	15	14
November 10	11.1	23	26	10.7	20	16	15
November 20	7.2	21	17	19.2	34	28	26
November 30	6.6	19	16	13.5	23	19	19
December 10	7.8	20	18	10.5	21	18	18
December 20	11	23.5	19	12	22	21	19
December 30	12	21	20	16.5	25	24	24

Statement showing least channel depths, etc.—Continued.

Date.	1886.					1887.				
	L. P. gauge-readings.	Dunnoansby Crossing.	Stack Island Crossing.	Ben Lomond Crossing.	Wilderness Crossing.	L. P. gauge-readings.	Dunnoansby Crossing.	Wilderness Crossing.	Stack Island Crossing.	Ben Lomond
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*F*
January 10	17.2	27	24	24	....	12.7	20	21	19	
January 20	22.5	32	31	27	....	7.8	17	18	15	
January 30	21.5	31	29	32	....	14.8	29	28	24	
February 10	20.5	27	27	24.5	....	28.7	40	43	37	
February 20	27.5	35	33	27.5	....	32.7	52	41	42	
February 28	31.7	38	32	31.7	....	35.7	50	38	43	
March 10	32	42	29	38	....	36.2	53	40	45	
March 20	25	30	27	34	....	....	....	....	....	....
March 30	22.5	23	27	35	....	37.8	50	40	43	
April 10	32.2	40	36	32.2	....	33	40	26	35	
April 20	35.5	41	39	35.5	....	23	29	20	25	
April 30	37.5	43	38	35.7	....	24	31	33	24	
May 10	37.5	45	40	43	....	31.5	37	33	35	
May 20	35.5	43	38	44	....	29	34	29	31	
May 30	35.2	39	37	42	....	21	28	21	23	
June 10	27	31	28	32	....	14.5	22	18	17	
June 20	21	28	21	29	....	16.5	23	21	19	
June 30	23	32	25	32	....	17	23	21	19	
July 10	24.5	28	24	31	....	....	....	....	....	....
July 20	17	22	16	21	....	....	....	....	....	....
July 30	12	18	11	16	....	....	....	....	....	....
August 10	10	15	11	15	....	....	....	....	....	....
August 20	8	16	10	12	....	....	....	....	....	....
August 30	7.8	18	11	15	....	....	....	....	....	....
September 10	6.6	16	9.5	15	....	....	....	....	....	....
September 20	5.3	15	9	12.5	14	....	....	....	....	....
September 30	4.7	13	8.5	11.5	12	....	....	....	....	....
October 10	5	14.5	9	12	12	....	....	....	....	....
October 20	....	....	....	....	....	....	....	....	....	....
October 30	2	10.5	11	10	12	....	....	....	....	....
November 10	2.8	11	11	11	10.5	....	....	....	....	....
November 20	2	10.5	12.5	9.5	9.5	....	....	....	....	....
November 30	12.3	23.5	19.5	18	18.5	....	....	....	....	....
December 10	15.7	26	20	20	24	....	....	....	....	....
December 20	6.8	21	11	12	12.5	....	....	....	....	....
December 30	14.6	32	21	17	34.5	....	....	....	....	....

NOTE.—No soundings were taken on the crossings from January to August, 1884, or from Ma
June, 1885, the river being above midstage.

The least depths found anywhere on the reach were as follows: 1884, Stack Is
Crossing, 10 feet; 1885, Ben Lomond Crossing, 13 feet; 1886, Stack Island Crossin
feet.

During 1879 the lowest point reached on the Lake Providence gauge was 0.55
and at that time there was only 5 feet on Stack Island Crossing.

The lowest readings of the gauge were in 1884, 5.23 feet; 1885, 5.54 feet;
2.55 feet.

Low water of 1887 has not yet been reached, the lowest reading yet reached b
on January 20, 7.8 feet, at which time the shoalest crossing was Ben Lomond, 10

CHANGES IN CHANNEL AND SHORE-LINES.

A comparison of the low-water surveys of 1882 and December, 1886, has be
made by Assistant Engineer Hider, and the drawings and text have been furnish
to each member of the Commission.

The low-water channels of this year do not differ materially from those of la
year. I would, however, call attention to the new channel forming near the cotto
wood system, and to the fact that the tow-head and bar in front of Lake Providen
is pushing down-stream.

Caving banks.—The principal caving on the right bank has been in Louisia
Bend, at Elton and at Judge Wyly's; on the left bank, on the upper side of Sarah
Island, between R. 30 and R. 36, at Mayersville Island, and at Shipland.

In September, 1886, I was ordered to prepare a general project for work in th
third district, under appropriations made by act of August 5, 1886, and submit th

same to the Mississippi River Commission, at meeting held by them in New York, September 16, 1886. This was done, and an allotment made by the Commission and approved by the Secretary of War.

A project was prepared and submitted for the expenditure of this money, and, with certain conditions, was approved by the Commission at their meeting in Saint Louis, Mo., November 26, 1886. I was afterwards directed, however, before expending these amounts, to furnish detailed projects and estimates. Under these orders I prepared and forwarded to each member of the Commission projects, in each case accompanied by maps and plans, as follows: Repairs to revetment at Pilcher's, December 21, 1886, and January 17, 1887; repairs to Cottonwood dikes, January 29, 1887; repairs to Bolesbed dikes, February 23, 1887; building deflecting dike at Lake Providence, January 29, 1887. None of these projects, however, have been approved by the Secretary of War.

Extensive repairs have been made to the plant and some supplies bought, such as rope, etc. Repairs to plant began in September, 1886, and were suspended May 1, 1887. The fleet is now in serviceable condition, needing only some supplies, such as rope, etc., which, from their perishable nature, should be bought at the last moment. The property must deteriorate, and will need more repairs before long.

The following is a list of the principal repairs made:

Fifteen quarter-boats calked above light water; of these new canvas roofs were put on 6.

One quarter-boat taken out on dock; bottom and sides calked.

Ten mattress-boats calked above light water; rotten places in gunwales cut out and replaced with new material; new skids made for same and boats painted.

One large machine-shop fitted up with new shafting, two new forges, and the machinery from the old shop.

One small pump-boat taken out on dock; sides and bottom calked and painted; new roof.

One large pump-boat taken out on dock; new sides, deck-frames, and hog-chains.

One grader, No. 1, taken out on dock; rotten parts of gunwales and decks replaced with new material; bottom, sides, and deck calked; machinery overhauled, pump cylinder repaired and put in working order; outside painted and new canvas roof put on.

One grader, No. 3, taken out on dock; rotten parts of gunwales and decks replaced with new material; sides and deck calked; two new water-cylinders put in place; other parts of machinery repaired; new canvas roofs put on and stage repaired; outside painted.

One large floating dock; new platform and truss built to support machinery; pumps and machinery repaired; new boiler put up, machinery and boiler moved farther forward; sides and rakes calked; gate repaired, etc.

Sixteen pile-drivers; rotten places in gunwales and decks replaced with new materials; leads and braces repaired; new hog-chains put in 5 drivers; machinery overhauled and repaired; new canvas roof put on; calked above light water, and outsides painted.

Thirty-three square barges; rotten places in gunwales and decks replaced with new material; calked above light water; 28 of these were painted.

Ten model barges; rotten places in gunwales and decks replaced with new material; calked above light water, and painted.

Steam-boat *Vidalia;* new roof; new after cabin built; calked above light water; machinery repaired and outside painted.

Steamboat *Osceola;* new furnace; roof repaired; capstan and other parts of machinery overhauled; wheel repaired; calked above light water, and painted inside and out.

Steam-boat *Meter;* new roof; calked above light water; wheel repaired, and outside painted.

Three yawls repaired and painted.

Ten skiffs repaired, calked, and painted.

One snag-boat, *Henry Sheldon*, docked and repaired.

Seventeen boats, consisting of coal barges and other boats, were calked and repaired for light service, not being considered worth more thorough repairs.

In addition, a number of minor repairs to different portions of the plant were made, not enumerated above.

Statement showing cost of labor and subsistence for care of fleet and repairs to same

Classification.	Pay-roll.	Subsistence.	Total.
Care of fleet and minor repairs	$20,041.93	$3,449.34	$23,491.27
Repairs to plant	17,266.89	2,153.37	19,420.26
Surveys, Lake Providence Reach	3,149.56	447.36	3,596.92
Moving rock at Arkansas City	275.22	77.13	352.35
Total	40,783.60	6,127.20	46,860.80

The cost of material used in repairs was	$10,724.62
Labor cost as above	19,420.26
Total cost of repairs	30,144.88

The highest number of men employed at any one time was 136; the least number 35.

Average cost of subsistence.

Cost of raw material, each ration	$0.[illegible]
Cost of each ration served	.[illegible]
Cost of ration for each day's labor secured	.[illegible]

Material expended.

Articles.	Quantity.	Articles.	Quantity.
Coal ... bushels	26,876	Solder ... pounds	16
Linseed oil ... gallons	384	Chalk ... do	35
Shingles	6,000	Borax ... do	5
Mineral paint ... gallons	1,200	Waste ... do	500
Paraffine ... do	5	Paraffine roofing ... yards	1,[illegible]
White-lead ... pounds	10,750	Iron ... pounds	21,[illegible]
Lumber ... feet	137,010	Tarred rope ... do	1,[illegible]
Fire-clay ... barrels	5	Gas pipe ... linear feet	1,[illegible]
Charcoal ... do	5	Fire-brick	1,[illegible]
Boiler tiles	50	Putty ... pounds	[illegible]
Wire rope ... linear feet	200	Screws ... gross	150
Lime ... barrels	10	Canvas ... yards	8,[illegible]
Turpentine ... gallons	50	Spikes and nails ... pounds	6,[illegible]
Salt ... barrels	258	Oakum ... do	1,100
Tin ... box	1	Finishing nails ... do	[illegible]
Leather ... sides	4	Glass ... feet	[illegible]
Lamp black ... pounds	10	Tacks ... dozen packages	165

List of barges, pile-drivers, tow-boats, etc., constituting floating property belonging to Lake Providence Reach.

Classification.	No.	Total.	Dimensions.	Classification.	No.	Total.	Dimensions.
Tow-boats (one in general				Wharf-boat	1	1	160 x [illegible]
service department)	4	4	....	Pump-boat (steam)	1	1	47 x 12
Graders (steam)	2	3	100 x 30	Barges (decked)	8	33	120 x [illegible]
Graders (small)	1		80 x 16	Do	23		100 x [illegible]
Mattress-boats	4	7	160 x 30	Do	2		160 x [illegible]
Do	2		200 x 30	Do	6	7	75 x 15
Mattress-boat (old)	1		140 x 49	Do	1		66 x 15
Screen-boats	4	4	100 x 25	Barges, model	10	10	140 x [illegible]
Quarter-boats	10	15	130 x 25	Pile-drivers	12	16	70 x [illegible]
Do	1		100 x 30	Do	4		62 x [illegible]
Do	1		135 x 30	Catamaran	1	1	....
Do	2		80 x 20	Calking flats	9	9	25 x [illegible]
Do	1		70 x 18	Yawls	7	7	....
Machine-shop boat (old)	1	2	100 x 20	Skiffs (old)	32	32	....
Machine-shop boat (new)	1		211 x 35	Coal barges, open (old)	2	2	130 x 25
Carpenter-shop boat	1	1	211 x 25	Coal barges, decked (old)	10	10	130 x 25
Dock	1	3	186 x 50	Scows, small	2	2	....
Do	1		87 x 16				
Do	1		27 x 8	Total	....	170	....

SURVEY.

A survey of the reach was made and copies of the map sent to each member of the Commission May 16, 1887.

GAUGES.

On May 1, 1887, the gauges at Clarendon and Arkansas City, Ark., and Greenville and Yazoo City, Miss., were placed under this office, to be paid for from money belonging to Lake Providence Reach. Inspector Clark has just finished inspecting them.

II. VICKSBURG HARBOR.

The work here consists of the improvement of the basin and channel in Centennial Lake and the maintenance of Delta Point, Louisiana, opposite Vicksburg. The retention of Delta Point is deemed essential to prevent further recession of the river from Vicksburg, and to maintain the regimen of the river immediately below.

As stated in my last annual report, a small break existed in the Delta Point revetment. At the meeting of the Mississippi River Commission in New York, September, 1886, an allotment of $5,000 was made for this repair work. Work was begun on October 21, 1886, and finished November 30, within the allotment, and the work is now reported in good condition. The following work was accomplished and material expended:

Brush and poles cut	cords..	125
Grading	cubic yards..	1,250
Stone	do....	1,010
Subaqueous mat built and sunk	square feet..	4,082
Revetment built in place	do....	6,900
Revetment ballasted	do....	40,750

This work will probably, however, need slight annual repairs.

By the river and harbor act approved August 5, 1886, $75,000 was appropriated for Vicksburg Harbor, as follows:

" * * * Seventy-five thousand dollars in deepening the channel at Vicksburg by dredging through the bar existing there; but this last named sum shall not be expended unless, after another examination or survey, the Commission shall deem it advisable; and if they shall not, then $37,500 shall be expended in the improvement of navigation at Vicksburg by constructing suitable dikes and other appropriate works. * * * ."

An allotment was made by the Commission, at their meeting in New York in September, 1886, of $2,500, to make the survey required, and it was intrusted to this office. The survey extended from below Vicksburg Harbor to the head of Paw Paw Island. It was finished in March, 1887, and on March 18, 1887, copies of my report, with accompanying maps, were sent to each member of the Commission.

Up to the end of the fiscal year no vote was taken on a project for this work. At a meeting of the Commission, held in New York in June and July, 1887, a project prepared by me was adopted by the Commission, and has since received the approval of the Secretary of War.

III. GREENVILLE HARBOR.

By the river and harbor act approved August 5, 1886, $37,500 was appropriated to prevent caving in front of the town of Greenville, Miss. An examination of the site was made by me, and a report rendered to the Commission at their meeting in September, 1886. It was decided by them that, owing to the small amount of the appropriation, no work should be done.

During the last high water considerable caving has taken place, and in April, 1887 by a vote of the people of Greenville, it was agreed to bond the city for $50,000 to assist in the work, provided the Mississippi River Commission would permit the appropriation to be spent; all work to be under this office. I prepared a plan for the work by revetting the bank, stating that in my opinion the work would last until the island above Greenville caved away. Assistant Engineer Hider prepared a project for the work, which I laid before the Commission.

At the meeting of the Commission in June and July, 1887, I was directed to prepare a project for this work by use of submerged dikes. In obedience to this order I submitted a plan which was adopted by the Commission, and which has since received the sanction of the Secretary of War.

IV. LEVEES.

The levees in the third district are called on the Mississippi side levees Yazoo Front, and on the Arkansas and Louisiana side levees Tensas Front.

Levees Yazoo Front.—Under an allotment of $12,000 made by the Board of Engineer Officers on Building and Repair of Levees, approved by the Secretary of War November 20, 1886, a portion of the Ben Lomond Loop was built under contract. Bids were opened November 29, and the contract awarded to J. L. Perkins, at 17 cents per cubic yard, the lowest bid received. The following is an abstract of bids received:

	Per cubic yard.
James L. Perkins, Duncansby, Miss	$0.17
George Arnold & Co., Memphis, Tenn	.17¾
J. J. Cooney, Memphis, Tenn	.20
Thomas F. and Henry Duffin, Memphis, Tenn	.20

The contract was finished and the work accepted early in February, 1887. As the material composing this levee is poor sand and sand loam, it was deemed advisable to do some additional work in building a berme and a protection levee; this was done by days' labor and by verbal agreements during high water.

As immediately connected with these levees, a survey was made of the caving bank in the vicinity of Lake Bolivar, where the large levee is threatened. The Secretary of War approved of using a portion of the allotment for this purpose. A report on this survey was forwarded, with map and estimate for protecting the bank, to the Commission May 18, 1887.

At Arkansas City the levees on the banks of the river approach within about 1 mile of each other. It was deemed well to measure the discharge here. The following was found:

Date.	Location.	M. R. C. engineer's gauge.	Slope per foot.	Mean velocity per second.	Area.	Discharge per second.
1887.			*Foot.*	*Feet.*	*Sq. feet.*	*Cu. feet.*
Mar. 22	Arkansas City	46.59	.000081	6.138	232,903	1,4[illegible],111
23	......do	46.60	.000080	6.287	233,565	1,46[illegible]
24	......do	46.61	.000081	6.023	247,655	1,491,7[illegible]
25	......do	46.63	.000078	(?)5.856	(?)240,921	(?)1,410,[illegible]
26	......do	46.68	.000076	6.122	234,187	1,43[illegible]
26	......do	46.68	.000076	6.052	234,187	1,417,40[illegible]
Apr. 19	Wilson's Point	23.40	....	3.968	139,309	552,7[illegible]

Levees Tensas Front.—On this front levees were built in whole or in part under this office from Amos Bayou to Linwood, a loop at Leland, and topping near Lakeport, all in the State of Arkansas. In addition to this, several loops were built in Louisiana under the local organizations.

Amos Bayou to Arkansas City.—It was estimated that to close the gaps in this line and to raise the existing levee to a grade of 1 foot above the high water of 1882 $35,000 would be needed. An allotment of this amount was made by the Commission at their meeting in New York, September 1886. It received the approval of the Secretary of War on November 5, 1886. The work was advertised, and on November 16, 1886, a contract entered into with the Tennessee Industrial Company to do the work for 22 cents per cubic yard.

	Per cubic yard.
George Arnold & Co., Memphis, Tenn	$0.26½
J. C. Cooney, Memphis, Tenn	.28
Tennessee Industrial Company, by John Q. Adams, president, Memphis, Tenn	.22
Thomas F. Duffin and Henry Duffin, Memphis, Tenn	.27

The work was begun on November 22, with every prospect of having the levee in good condition for the expected high water. Owing, however, to bad management and bad weather the rise came even before the gaps had been closed. By strenuous efforts the gaps were closed in face of the water, although in several places the river flowed through for several hours. After the high water was over a thorough reorganization of the force was made, but up to June 30 only about 130,000 cubic yards have been placed. It is believed that this contract will be completed early in August, 1887. To this levee I have given the name of the Opossum Fork Levee.

Levee from Arkansas City to Gaines Landing.—This levee is known by several names applied to parts of it, such as the "Winter," the "Eunice," the "China," etc. For convenience I call this whole line the Eunice Levee.

This work was superintended under this office, and the work done by Duffin Bros., of Memphis, Tenn., under a contract made by the Tensas Basin Levee commissioners, of Louisiana, at 26 cents per cubic yard. Work was begun in December, 1886, and continued until stopped by high water in March, 1887. The principal gaps closed were at Old Eunice Landing and at Boggy Bayou; 130,751 yards were finished. After high water work was suspended, and will be resumed in September.

Panther Forest Levee.—This levee is intended to close the gap existing between Gaines Landing and Linwood, Ark.

This work was advertised and contract awarded to the lowest bidders, George Arnold & Co., of Memphis, Tenn., on November 29, 1886, at 19 cents per cubic yard. Abstract of bids received follows:

Name and address of bidder.	Price per cubic yard.	
	To be finished March 20, 1887.	To be finished December 25, 1887.
	Cents.	*Cents.*
Robert E. Craig, Chicot, Ark	30	22½
Thomas O'Malley, Donaldsonville, La	27	25
Tennessee Industrial Company, Memphis, Tenn	27	24
John S. McTighe, Isaac L. McKee, Memphis, Tenn	30	22
George Arnold & Co., Memphis, Tenn	23½	19
John McGinty, New Orleans, La	24	20
Thomas F. Duffin & Bro., Memphis, Tenn	....	21½

Work was begun early in January and prosecuted until stopped by high water. It was resumed April 25, and is now being pushed; 70,000 cubic yards have been placed. After beginning this work it was found advisable, on account of threatened banks and bad material, to change the location. As this change increased the amount of clearing very materially and decreased the size of levee in the open, a supplementary contract was made, giving the contractors $60 per acre for clearing. This contract was approved by the Secretary of War on March 2, 1887.

Leland Short Line.—This work was advertised and contract made with Stansell and Forrest, of Memphis, Tenn., on December 25, 1886, at 17¾ cents per cubic yard, to be finished March 20, 1887. Abstract of bids received follows:

Name and address of bidder.	Price per cubic foot.	
	To be finished March 20, 1887.	To be finished December 25, 1887.
	Cents.	*Cents.*
Robert E. Craig, Chicot, Ark	18	16¾
Daniel T. Hartnett, Memphis, Tenn	....	25
Riley & Walsh, Saint Louis, Mo	19	18¾
P. H. Winters, P. Cooney, Memphis	....	19¾
L. C. Dulaney, Rosedale, Miss	....	13$\frac{9}{10}$
Thomas O'Malley, Donaldsonville, La	27	25
Tennessee Industrial Company, Memphis, Tenn	26	23
John S. McTighe, Isaac L. McKee, Memphis, Tenn	30	22
Michael Hughes, Vicksburg, Miss	23	19
George Arnold & Co., Memphis, Tenn	20	17
John McGinty, New Orleans, La	19½	17½
Thomas F. Duffin & Bro., Memphis, Tenn	....	18
William M. Forrest, Jeptha W. Stansell, Memphis, Tenn	17¾	....

Work was begun early in January, but owing to the over-confidence of the contractor was not finished on time. This levee, although at that time above the level of the water, broke on March 21, flooding the country immediately behind. After the subsidence of the water work was again resumed, and it was finished and accepted on May 17, 1887.

With a protection levee that it was found necessary to build, and ditches for draining the site, the yardage in this levee was 98,000 cubic yards.

Lakeport Levee.—This work, superintended under this office, was done by Mr. Ford, of Lakeport, Ark., under contract made by the Chicot County levee board. The only work was topping and enlarging near Lakeport. Cost, $2,339.

Protection of levees from damage during high water.—The Board of Engineer Officers on Building and Repair of Levees allotted $18,000 to that purpose in the third district.

During high water sacks, lumber, and other supplies were purchased, and the steamers *Vidalia* and *Meteo* were used for moving them and laborers to threatened points.

A break occurred at the Bigg's Levee, Louisiana, nearly opposite Vicksburg. The ends of the break were revetted. The break at Leland was similarly treated. Some work was done all along the levees in Arkansas, but especially at the Opossum Fork Levee. Here the struggle was severe; the water rose from ½ to 1½ feet above any previous water, and it was only by most persevering and incessant work that the line was held. Thirty-six thousand sacks and several thousand feet of lumber were used. From 300 to 400 men were employed. In this case the judgment and energy of Assistant Engineer Tollinger, Rodman Kilpatrick, and Inspector Coney, can not be too much commended. Mr. H. C. Smith, an employee of the contractors, and Mr. Ross, on the part of the Desha County levee board, were of the greatest service.

Below Arkansas City, on the Eunice Levee, Assistant Engineer Goodrich and Inspector Currie held the line, and by great exertion prevented much loss, especially in unfinished parts.

There was expended on all the levees about $13,000.

Financial statement, third district, from November 1, 1886, *to June* 30, 1887.

LAKE PROVIDENCE REACH.

Allotment	$270,000.00	
Transferred from Delta Point allotment	1,000.00	
Deposit for overpayment	.20	
		$271,000.20
Expenditures:		
Services	24,927.55	
Fuel	5,249.88	
Plant, tools, and repairs	3,228.75	
Material and supplies	277.33	
Subsistence	2,819.44	
Repayment to other allotments	2,521.50	
Miscellaneous	1,280.36	
	40,304.81	
Liabilities	3,217.63	
		43,522.44
Available balance		227,477.76

REPAIRS TO FLOATING PLANT.

Allotment		30,000.00
Expended prior to November 1		3,162.85
Balance		26,837.15
Expenditures:		
Services	$13,639.08	
Plant, tools, and repairs	10,627.97	
Subsistence	1,811.29	
Material and supplies	257.75	
Miscellaneous	501.06	
		26,837.15

VICKSBURG HARBOR.

Available balance November 1		60.59
Expenditures:		
Plant, tools, and repairs	$56.13	
Miscellaneous	4.46	
		60.59

SURVEY, VICKSBURG HARBOR.

Allotment	$2,500.00	
Expended prior to November 1	5.05	
		$2,494.95
Expenditures:		
Services	1,936.41	
Miscellaneous	103.19	
Subsistence	75.67	
Material and supplies	26.43	
Plant, tools, and repairs	14.25	
Fuel	9.00	
Charter boats and barges	330.00	
		2,494.95

REPAIR OF DELTA POINT, LOUISIANA.

Allotment		$5,000.00
Expenditures:		
Services	$3,061.98	
Miscellaneous	153.32	
Subsistence	472.78	
Material and supplies	182.77	
Plant, tools, and repairs	2.75	
Fuel	94.50	
Transferred to Lake Providence allotment	1,000.00	
		4,968.10
Balance		31.90

LEVEE, AMOS BAYOU TO ARKANSAS CITY.

Allotment		38,500.00
Expenditures:		
Services	$1,827.83	
Contractors' estimates	25,542.00	
Miscellaneous	740.16	
	28,109.99	
Liabilities	3,390.01	
		31,500.00
Available balance		7,000.00

LEVEES, ARKANSAS CITY TO LOUISIANA LINE.

Allotment		94,920.86
Expenditures:		
Services	$3,420.24	
Contractors' estimates	26,620.46	
Plant, tools, and repairs	5.25	
Miscellaneous	611.72	
	30,657.67	
Liabilities	14,263.19	
		44,920.86
Available balance		50,000.00

LEVEES, YAZOO FRONT—BEN LOMOND HOOP.

Allotment		12,000.00
Expenditures:		
Services	$2,046.82	
Contractors' estimates	7,390 05	
Material and supplies	961.76	
Plant, tools, and repairs	27.37	
Subsistence	31.50	
Miscellaneous	325.73	
		10,783.23
Available balance		1,216.77

LEVEES, TENSAS FRONT.

Amount available November 1		213.90
Expenditures:		
Plant, tools, and repairs	$125.60	
Miscellaneous	44.42	
		170.02
Available balance		43.88

PROTECTION OF LEVEES.

Allotment		$18,000.00
Expenditures:		
Services	$8,589.19	
Material and supplies	3,347.28	
Subsistence	411.84	
Plant, tools, and repairs	255.46	
Fuel	176.92	
Charter of steamers and barges	43.50	
Miscellaneous	252.83	
		13,077.02
Available balance		4,922.98

RECAPITULATION—AVAILABLE BALANCES JUNE 30, 1887.

Lake Providence Reach	227,477.76
Opossum Fork Levee	7,000.00
Arkansas City to Louisiana line	50,000.00
Ben Lomond Hoop	1,216.77
Repairs of Delta Point	31.90
Levees, Tensas Front	43.88
Protection of levees	4,922.98

By reallotment of the Commission June 30 and July 1, 1887, the available balance for Lake Providence Reach was decreased to $28,000; Opossum Fork Levee increased to $60,000, and the following additional allotments made, viz:

Vicksburg Harbor	$72,500
Greenville Harbor	37,500
Repairs to Delta Point	10,000
Protection of existing works	25,000

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, third district.

Class of property.	No.	Approximate value June 30, 1887.
Steam tow-boat *Osceola*	1	$17,000
Steam tow-boat *Vidalia*	1	15,000
Steam tow-boat *Emma Etheridge*	1	11,000
Survey-boat *Meter*	1	6,000
Hydraulic graders	2	30,000
Mattress-boats:		
160 by 30 feet	6	14,400
140 by 49 feet (old)	1	800
Screen-boats	4	3,600
Quarter-boat (with outfit):		
135 by 30 feet	1	3,250
130 by 25 feet	10	25,000
100 by 30 feet	1	1,800
80 by 20 feet	2	2,500
70 by 18 feet	1	400
Machine-shop boat	1	4,500
Machine-shop boat (old)	1	250
Carpenter-shop boat, with outfit	1	2,700
Floating dry-dock, with machinery	1	3,000
End-docks, 37 by 16 and 27 by 8 feet	2	850
Pump-boat and machinery	1	800
Small scows	2	50
Barges (decked and scow-built)	35	44,350
Barges (model)	10	32,725
Pile-drivers (with machinery)	16	44,000
Catamaran	1	75
Calking-flats	9	100
Yawls	7	400
Skiffs	34	272
Coal barges and boats (old)	12	2,000
Tools and appliances (including drawing instruments)	......	750
Surveying instruments	......	2,000
Total	......	263,322

List of civilian engineers employed on works of river and harbor improvement in charge of Capt. William T. Rassell, Corps of Engineers, U. S. A., from October 31, 1886, *to June* 30, 1887, *inclusive, under the river and harbor appropriation act approved August* 5, 1886.

Name and residence.	Time employed (months).	Compensation per month.	Where employed.	Work on which employed.
	M. d.			
Arthur Hider, Louisville, Ky.	8	$200	Wilson's Point, La.	In local charge of and superintending repairs to fleet.
William M. Childs, Chicago, Ill.	4 13	150	Wilson's Point, La. Bolivar, Miss. Arkansas City, Ark	Survey of Lake Providence reach. Survey of Bolivar Landing. In charge of current observations.
C. P. Ruple, near Wilson's Point, La.	5 14	150	Wilson's Point, La.	In charge of survey Lake Providence reach and preparation of maps.
H. St. L. Coppée, Vicksburg, Miss.	4 2	175 125	Vicksburg, Miss...	In charge of survey of Vicksburg Harbor and repairs to Delta Point, La.
E. C. Tollinger, Wrightsdale, Pa.	7 20	150	Near Arkansas City, Ark.	In charge of construction and repair of levee from Arkansas City to Amos Bayou.
Henry Goodrich, Lake Providence, La.	5 18	150	Gaines Landing, Ark. Linwood Landing, Ark.	Construction of Eunice levee, Ark. Construction of Panther Forest levee, Ark.
James Elliott, Memphis, Tenn.	1 9	150	Linwood, Ark	Construction of Panther Forest levee.

Respectfully submitted,

Wm. T. Rossell,
Captain of Engineers.

Appendix F.

REPORT OF CAPTAIN DAN C. KINGMAN, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FOURTH DISTRICT.

United States Engineer Office,
New Orleans, La., July 30, 1887.

Colonel: I have the honor to transmit herewith my report of operations for fiscal year ending June 30, 1887, for works in my charge in the fourth district, Mississippi River.

Very respectfully, your obedient servant,

Dan C. Kingman,
Captain of Engineers.

Col. Q. A. Gillmore,
Corps of Engineers,
President Mississippi River Commission, New York City.

REPORT.

The charge of the fourth district, Improving Mississippi River, was transferred to me by Maj. Charles W. Raymond, Corps of Engineers, on December 4, 1886, by virtue of Special Orders No. 265, paragraph 6, Headquarters of the Army, Adjutant-General's Office, dated Washington November 13, 1886.

I.—Improvement of the Harbor at New Orleans, La.

The adopted projects for work in New Orleans Harbor are, first, to cover the caving bank in the Carrollton Bend, for a distance of 10,000 linear feet, with a mattress of willow brush, ballasted with stone; second, to protect the portion of bank known as the Gouldsboro Bend, about 5,000 linear feet, by means of sloping submerged spurs, made mostly of brush and stone, and placed at intervals, which are as yet

experimental, varying from 500 to 1,600 feet. It is also proposed to protect in like manner the Gretna Bend and the Great Bend above Gretna.

At date of last annual report, June 30, 1886, the condition of the work was as follows:

A small portion of the brush mattress in the Carrollton Bend had been laid. Two spurs had been completed, and the foundation mattress and two cribs of a third had been placed in the Gouldsboro Bend.

A plant for the mattress work had been acquired, and nearly all the stone for ballast, iron rods, and other material, except brush, for the completion of the six spurs originally contemplated in the Gouldsboro Bend was on hand.

A survey had been made, which developed the fact that the 100-foot contour had been thrown out from the bank, and that the spurs were in good condition and apparently accomplishing the results for which they were built.

Owing to lack of funds no work had been done since November, 1884, except such as was necessary for care and preservation of property.

On August 5, 1886, additional funds were appropriated by Congress, and a project for continuance of the work was prepared and submitted to the Commission. It was approved September 20, 1886.

This project was in substance as follows:

(1) To place the plant in serviceable condition.

(2) To re-survey the site of the spurs built and to be built in the Gouldsboro Bend, to ascertain whether changes had taken place which would make a re-location of the unconstructed spurs desirable.

(3) To complete the unfinished spur and construct the three remaining spurs.

The commission directed the new spurs to be built first, so as to take advantage of low water, and complete the unfinished spur afterwards, which it was thought could be done at high water.

On October 6, 1886, the work of repairing the plant was commenced. Owing to the length of time that the barges and boats had been laid up these repairs were quite extensive, and the plant was not ready for service until the latter part of November.

The survey of the Gouldsboro Bend was commenced October 14 and completed November 3. The whole area under improvement was carefully sounded. The condition of the spurs already built was found to be good, and no changes that would render necessary a re-location of the unconstructed spurs were developed.

The spurs built in the fall of 1884 were numbered, respectively, 2, 3, and 5, the last being incomplete, consisting of a foundation mattress and two cribs. On November 29, 1886, the construction of Spur Dike No. 1 in the Gouldsboro Bend was commenced, but it was not completed until January 6, 1887, owing to the slow delivery of brush by the contractors.

Construction of Spur No. 6 was commenced January 7, 1887, and it was completed on February 3, 1887. By this time the river had commenced to rise and heavy drift was running, making the work of sinking the mattress and cribs exceedingly difficult and expensive. It was intended to finish Spur No. 5 (partially completed in 1884), and three cribs had been built for that purpose. The plant was moved into position on February 7, but owing to the great quantity of heavy drift running it was found to be impossible to sink the cribs on the spur. As the cribs would otherwise have been lost it was decided to sink them immediately below Spur No. 3. Accordingly the three cribs were sunk so as to carpet the bank from a low-water depth of 35 feet to a depth of 75 feet. The up-stream ends of the cribs lapped upon the foundation mattress of Spur No. 3.

The season's work resulted in the completion of two new spurs, Nos. 1 and 6, which is rather more than was expected, considering the lateness of the season when work was commenced.

There were constant delays caused by the slow delivery of willow brush by the contractors, and the cost of the work was thereby somewhat increased.

The methods of constructing and sinking the mattresses and cribs were the same as in 1884, except that the cribs were built and launched from floating ways instead of on ways on the bank. The float had just enough buoyancy to support the crib timbers and the first layer of willow brush. This method was found to be cheaper and better than the old one.

The average cost of Spurs Nos. 1 and 6, exclusive of cost of plant, was $10,460. Less than half the quantity of rock per spur was used than in 1884. This sum represents the actual cost of the spurs, and does not cover the office expenses or the care of plant when not in use.

On February 14 all work on spur-dikes was suspended, and the plant moved to secure laying-up quarters. All the tools and material were placed in good condition and stored in readiness for next season's work. An amended project, which was approved (see report on rectification of Red and Atchafalaya rivers), called for the repairing of the barges composing the old mattress ways. Accordingly the ways have been taken off, the barges disconnected, repaired, and decked for use as stone and

willow barges. The hull and machinery of the launch *Alaska* have been repaired, and a new boiler is being built for her.

The total amount expended to June 30, 1886, is $150,199.40.

The estimated amount required for completion of the work in New Orleans Harbor is $620,000.

The amount that can be profitably expended during the fiscal year ending June 30, 1889, is $100,000.

The work is in the collection district of New Orleans.

The nearest light-house is at the mouth of the Mississippi River.

The collector of the port furnishes the following statistics of the commerce of New Orleans:

CUSTOM-HOUSE, NEW ORLEANS, LA.,
Collector's Office, July 9, 1887.

SIR: In accordance with your request of the 22d ultimo, I submit herewith statements showing the transactions of customs business at this port during the fiscal year ending June 30, 1887:

Entrances and clearances of vessels during fiscal year ending June 30, 1887.

	Entered.		Cleared.	
	No.	*Tons.*	*No.*	*Tons.*
Steam-vessels	758	980,493	676	977,395
Sailing vessels	301	177,033	251	160,882

Imports and exports during fiscal year ending June 30, 1887.

IMPORTS.

Bullion	$58,195
Coin	194,246
Merchandise, free	5,242,907
Merchandise, dutiable	4,408,777

EXPORTS.

Foreign	479,071
Domestic	78,958,192
Total value of exports	79,437,263
Duties collected on imports	2,312,930
Customs receipts from all sources	2,367,502

* * * * * * *

Very respectfully,

B. F. JONAS, *Collector.*

Capt. D. C. KINGMAN,
United States Engineer Office, 3 *S. Rampart Street, New Orleans, La.*

FINANCIAL STATEMENT.

Improving Mississippi River (no limit)—New Orleans Harbor.

July 1, 1886, amount available		$2,007.65
Act of August 5, 1886, allotment		75,000.00
Total		77,007.65
July 1, 1887, amount expended during the fiscal year, exclusive of outstanding liabilities, July 1, 1886	$39,535.25	
July 1, 1887, outstanding liabilities	764.22	
		40,299.47
July 1, 1887, balance available		36,708.18

II.—RECTIFICATION OF RED AND ATCHAFALAYA RIVERS.

At the date of last annual report, June 30, 1886, no work was in progress at this locality.

No work in pursuance of any project for the permanent improvement of the rivers in this locality had been done, but each year temporary expedients had been resorted

to, to maintain a low-water channel through Old River between the Mississippi and the Red and Atchafalaya. These expedients did not always meet with success, and sometimes navigation was totally suspended.

Previous to the passage of the river and harbor act of August 5, 1886, no funds were available either for work at the mouth of Red River or for preparation therefor. The condition of things in this locality was, however, a matter of great solicitude to this office very early in the season. On August 2, 1886, report was made to the Commission as follows:

"Soundings made by steam-boat men in passing through Old River indicate that the channel from the Mississippi River to the crossing has silted up considerably during the past season's high water. Considering the rapid fall of the Mississippi River, it is probable that the navigation of Old River will be greatly obstructed if not entirely suspended before the end of August."

Instantly upon the passage of the river and harbor act, a report was submitted giving a statement of the condition of Old River on August 1. There was then a depth of 8 feet on the bar at the mouth, 7 feet near Ash Cabin, 4½ feet on the crossing, and 18 feet from the crossing to the head of the Atchafalaya. The river was falling at the rate of 6 inches per day, and there was a difference of level of about 1 foot between the two gauges at Red River Landing and at Barbre's, indicating a probable suspension of navigation by August 15. It was stated that there was a slight possibility of keeping the channel open if work was commenced without delay.

The headquarters of this office had been temporarily transferred to New York City, and on August 8 Maj. Chas. W. Raymond, then in charge, called personally on the president of the Commission, who, in anticipation of the approval of the Commission and of the Secretary of War, gave verbal orders to begin work at the earliest possible moment. Orders were immediately telegraphed to the assistant at New Orleans, who had been previously instructed to hold himself in readiness for immediate action, to commence preparations. But for this assumption of responsibility, it is reasonably certain that no work whatever would have been possible the past season in the channel of Old River.

The steamer *General Newton*, the only suitable vessel at the disposal of this office, was in such bad condition that she was not believed to be fit for service. She had been severely strained by the work of previous years, and no money had been available for her repair. However, as it was found practically impossible to charter a suitable boat, she was hastily strengthened for temporary use.

Preparations were pushed with such energy that the *Newton*, fully equipped, left for Red River on August 12, seven days after the passage of the river and harbor act.

In the mean time authority to borrow plant from the third district had been obtained, and, upon application, Captain Rossell promptly sent a pile-driver and three small barges to the mouth of Red River.

In anticipation of the breaking down of the steam-boat *General Newton*, which was liable to occur at any time, application was made for the steamer *Osceola*, belonging to the third district, but temporarily employed in the service of the Missouri River Commission. She was at work in the Missouri River, but was sent to the mouth of Red River with great promptness by the secretary of the construction committee. She arrived on September 13, and relieved the *Newton*, which boat returned to New Orleans for necessary repairs.

The working party arrived at the mouth of Red River on August 14, and as soon as the scraping apparatus could be rigged on the steamer, the channel examined, and a method of operations determined on, work was commenced August 17. From that time until October 28, when navigation was suspended, the work was vigorously carried on.

The methods employed were as follows: On the bar, at the mouth, the scraper was used until all the mud was removed. This method then being of no further use, piling was driven on the bar, to which the boats were secured, and the sand was washed away by turning their wheels with the current. A dike was constructed at the mouth to prevent the return of Mississippi water to the Mississippi after it had entered the mouth of Old River. At all wide places clear through to the Atchafalaya pile-dikes were built for the purpose of contracting the channel and producing scour. In all about 2,600 feet of pile-dike work was built.

These methods were successful until September 29, when the banks near Ash Cabin commenced sliding. This action forced up mud lumps and ridges in the channel, which, as the sliding increased in amount, became more and more difficult to remove. When it was no longer possible to remove these by the methods above mentioned, they were blown up with dynamite, but the rapid fall of the river and the continued rising of the lumps and ridges finally caused even this method to fail.

On October 28 further effective work by any of the above methods became impossible and navigation was virtually suspended.

The result of the work done by the United States during the past season in Old River is that a navigable channel was kept open for at least two months, during

which it would otherwise have been closed. On August 16, prior to the commencement of work, the channel had a least depth of 30 inches, the Red River Landing gauge reading 11.6 and the Barbre's Landing gauge 8.2. On September 30 there was the same least depth, although the river at Red River Landing had fallen to 6.1, and at Barbre's Landing to 3.5, and this was entirely due to the work done. On October 28, when navigation was virtually suspended, the Red River Landing gauge read 3.3. The lowest point reached during the season of 1885 was 6.4, when there was a 4-foot channel only.

The shoal water during the low-water season of 1886 was not as heretofore confined to two or three bars or flats, but was almost continuous from the Mississippi to the head of the Atchafalaya. It seems highly probably that the difficulty of maintaining navigation through Old River by dredging will increase from year to year, owing to the silting up of the channel.

Mr. H. S. Douglas, assistant engineer, was in immediate charge of the work, and for additional details I refer to his report herewith.

On August 21, 1886, a project was called for by the president of the Commission for the expenditure of the allotment of $187,500 for the "rectification of the Red and Atchafalaya rivers, by preventing further enlargement of the latter stream and restricting its outlet capacity, and for keeping open a navigable channel through the mouth of Red or Old River into the Mississippi."

A project was prepared in accordance with the general plan of the Commission (see Report of the Mississippi River Commission for 1884, page 26), and submitted to the Commission at its meeting in New York, September 20, 1886, as follows:

ROOM 52, ARMY BUILDING,
New York City, September 20, 1886.

COLONEL: In obedience to instructions contained in your letter of August 21, 1886, I have the honor to submit the following project for the commencement of work upon the "Rectification of the Red and Atchafalaya rivers," in conformity with the plans of the Mississippi River Commission. For this work and for keeping open the low-water channel in Lower Old River the sum of $187,500 is allotted in the act approved August 5, 1886.

The sum of $15,000 has already been allotted by the Commission for keeping open the channel of Old River during the present season, and it will probably all be expended. It is believed that the Commission will desire to reserve an equal sum for the same purpose during the next season. This leaves the sum of $157,500 available for application to the work proposed at the mouth of the Atchafalaya.

The plan of the Commission, so far as it relates to present work, contemplates the construction of six low dams in the Atchafalaya, which are to be begun by laying the sill-courses for all of them. (*Vide* Report of the Commission for 1885, page 2869.) The conditions which these dams must satisfy are stated in the report of the Commission for 1884, page 2560, and may be summarized as follows:

(1) They must all be located below the Bayou des Glaizes, the intervals between them not exceeding one-quarter of a mile.

(2) They must be built up to just below low water.

(3) Their height and the width between spurs is to be so adjusted that they shall permit the passage down the Atchafalaya of a volume equal to the flood discharge of Red River.

(4) The sills are to be not less than 300 feet wide up and down stream, and are to extend transversely up to the high-water banks. The dams are to be built upon them with concentric and diminishing cribs like those employed in New Orleans Harbor.

The following method of constructing and placing the sills for these dams is adopted for the purpose of estimating the cost of the work. It was prepared upon the ground by Assistant Engineers H. S. Douglas and W. G. Price under my specific instructions. It may be greatly modified as the result of experience in actual construction.

Each sill is to consist of a continuous series of ballasted mattresses, 300 feet wide up and down stream, extending to high-water mark from bank to bank, and cribs placed upon the mattresses at the banks, so as to form slopes of 1 on 3 from low-water mark to deep water. Before placing the mattresses the banks between high and low-water limits are to be graded to a slope of 1 on 3.

It is proposed to construct and place the mattresses as follows: Ways will be built at a convenient point above the site of the dams, upon which the mattresses will be constructed. Each mattress will be 18 inches thick, 300 feet long, and 75 feet wide. One foot of the thickness will be willow brush, the alternate courses laid at right angles to each other and tightly compressed, and 6 inches will be poles crossing each other at right angles, so as to form pockets for holding the stone ballast. The completed mattress will be launched and towed to its position, where it will be moored between barges loaded with stone, and sunk.

Commencing at the down-stream edge of the sill, it is proposed to lay a series of these mattresses end to end, so as to form a strip 75 feet wide entirely across the river.

Just above this, and possibly overlapping it, a similar strip will be laid, breaking joints with the first. Other strips will be laid in a like manner until the desired width of 300 feet has been attained. A second course of mattresses of similar dimensions will be then laid upon the first, being placed with their greatest length parallel to the current and across the first at right angles, so as to cover effectually any openings which might permit scour.

The cribs, to give a slope of 1 on 3 at the banks, will be placed upon the mattresses in the manner employed at New Orleans Harbor. These cribs are regarded as an essential part of the sill, and should not under any circumstances be omitted.

The probable cost of a single sill, exclusive of plant, is determined approximately as follows:

(1) *Grading the banks above low water.*—The present slope is generally very steep, and must be graded to a slope of 1 on 3 at each sill. The amount of excavation required has not yet been definitely determined, but is estimated at about 5,000 cubic yards at each sill. If a hydraulic grader can be borrowed from some other district this can be removed for about 2 cents per cubic yard, or about $100 per sill.

(2) *Mattress work.*—The average width of the river between high-water banks immediately below Bayou des Glaizes is about 1,300 feet, and the average length of the foundation mattress work, measured along the high-water wetted perimeter, will be about 1,400 feet. Hence each sill contains about 1,260,000 cubic feet of mattress work. Its cost in place is estimated at 5 cents per cubic foot. The total cost for each sill is therefore $63,000.

(3) *Cribs.*—The number of cribs required will be determined by the existing slope of the bank below low water in each locality. This is not definitely known, but it is estimated that 80,000 feet of crib-work will be required at each sill. The last cribs sunk in New Orleans Harbor cost 3.56 cents per cubic foot. At this price the cost of cribs in place for each sill will be $2,848.

The estimated cost of a single sill is therefore as follows:

Grading above low water	$100
Mattress work	63,000
Cribs	2,848
Total	65,948

The plant required for the work is as follows: Six barges for lowering mattresses and cribs, six general service barges for handling stone at the work, twenty-five barges for the delivery of stone and brush by the contractors, one propeller tug-boat for towing mattresses into position and handling plant, about 10,000 pounds of rope for lowering lines, etc.: Tools for mattress construction. It is assumed that such portions of the necessary outfit as are now on hand in the district will be used; for example, cooking utensils, blankets, ticks, lumber, etc. Temporary quarters will be required for the laborers. The cost of this plant is estimated as follows:

6 lowering barges, at $3,200 each	$19,200
6 stone barges, at $1,800 each	10,800
25 brush and stone barges, at $1,800 each	45,000
Tug-boat, about	7,000
Quarters for laborers, about	2,000
Rope, tools, etc	3,000
Total	87,000

Deducting the cost of plant from the amount available ($157,500) there remains $70,500, which is just about sufficient for the construction of a single sill.

The present working season is now so far advanced that little, if any, actual construction can be undertaken before the high water of 1887. I recommend that a survey of the site of the proposed sills be made at once; that the necessary plant be constructed or purchased; that the necessary quarters be constructed, and that arrangements be perfected for the supply of materials. The construction of a single sill is also recommended, should the Commission think proper to waive the condition expressed in its report of 1885.

Very respectfully, your obedient servant,

CHAS. W. RAYMOND,
Major of Engineers.

Col. Q. A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

This project was approved by the Secretary of War, October 1, 1886.

On March 14, 1887, for the reasons therein stated, the following modification of the original project was submitted:

UNITED STATES ENGINEER OFFICE,
New Orleans, La., March 14, 1887.

SIR: The approved project for the commencement of work upon the "Rectification

of the Red and Atchafalaya rivers" calls for the construction or purchase of the following plant:

6 lowering barges, at $3,200 each	$19,200
6 stone barges, at $1,800 each	10,800
25 brush and stone barges, at $1,800	45,000
1 tug-boat, at $7,000	7,000
Quarters for laborers	2,000
Rope, tools, etc	3,000
Total	87,000

After a careful study of the details of the work, and examination of the locality where the improvement is to be made, I have the honor to recommend the following modifications:

(1) That the laborers be lodged in quarter-boats instead of in huts on the bank. These boats can be moved about as may be necessary and moored in the most convenient places, so that the laborers need lose no time in going to and from their work. I have been informed by the district officers above that they have quarter-boats in excess of their requirements, and that, with the approval of the Commission, they could lend me two or three for this work.

(2) In regard to floating plant: The six lowering barges are now being built by contract at a cost of $2,787 each; when completed with capstans, etc., they will cost about $2,900, which is a little less than the estimate. The project, in addition, calls for thirty-one brush and stone barges at a cost of $55,800. I do not think that all of these are necessary, as I propose to collect all the stone that will be required and store it at some convenient place before the work is begun. I think, therefore, that eleven brush and stone barges will be all that will be required.

To obtain them: In the floating plant pertaining to New Orleans Harbor was an arrangement of eight barges, 20 feet by 100 feet each, rigidly framed together and provided with ways for the construction of continuous mattresses. This affair has been used during the past season in the construction of mattresses for the spur-dikes in the Gouldsboro Bend, but it is not very well adapted to this work, as it is very hard to move about; and, also, as the barges are placed side by side all the brush in the work has to be carried the whole length of a barge, thereby increasing the number of laborers required in mattress construction. These barges are beginning to decay and the ways are also giving out, and it has become necessary to separate them in order to repair and calk them. Now, if these barges were put in order, which could be done by hired labor and making use of such of the old material as is suitable, at a cost of about $1,300 for the eight, they would then make excellent brush and stone barges for the Atchafalaya.

I would therefore propose to build three barges of the model shown in the accompanying photograph, which will cost altogether about $10,000, and exchange them for the eight barges above described. This would give me an admirable mattress plant for New Orleans Harbor, and eight good barges for the Atchafalaya. The barges I now have are too narrow to have the ways placed on them, as shown in the photograph.

I would then propose to build three brush and stone barges for the Atchafalaya at a cost of $1,800 each.

The means of communication with Simmsport are exceedingly slow and uncertain. The nearest telegraph and railroad stations are at West Melville, where the Texas and Pacific Railroad crosses the Atchafalaya and Bayou Sara on the Mississippi. The former is 25 and the latter 50 miles away. In order to keep this office in daily communication with the work, I propose to repair the iron steam launch *Alaska*, belonging to New Orleans Harbor, and use it as a dispatch boat between West Melville and Simmsport. When not so employed it would be very useful in towing mattresses, etc. The launch requires a new boiler and certain minor repairs, which will cost in all about $500.

To recapitulate:

6 lowering barges, at $2,900 each	$17,400.00
3 brush and stone barges, at $1,800 each	5,400.00
Repairing 8 barges, at $1,300	1,300.00
Repairing launch *Alaska*, $500	500.00
Tug-boat	7,000.00
3 mattress barges for New Orleans Harbor	10,000.00
Total	41,600.00
Present project	87,000.00
Saving	45,400.00

For the maintenance of the low-water channel through Lower Old River during the coming season, I purpose to employ the steam-boat *General Newton* in scraping as

heretofore, and, with the approval of the Commission, to borrow a pile-driver fro one of the districts above, to be used in the construction of temporary spur dik I shall also make use of the launch *Ruby* as it may be required. I think it woul advantageous to the service if the Commission would cause a serviceable pile-driv to be permanently transferred to this work.

The tug *Tilda*, belonging to New Orleans Harbor, has been recently inspected a the hull found to be in very bad condition. It will cost to repair it about $5 I would request authority to put it in good order, paying from allotment for N Orleans Harbor.

I have at Carrollton a store-house which cost about $500. It is in danger of falli into the river on account of the caving bank. I would request authority to tak down and place it upon a barge. This will cost about $275. The barge could th be moored with the fleet, and the services of one watchman dispensed with.

If the above recommendations are approved, I would request that I may be notif as soon as possible, in order that the work of construction and repair may be co menced.

Very respectfully, your obedient servant,

DAN C. KINGMAN,
Captain of Engineer

Col. Q. A. GILLMORE,
Corps of Engineers, President Mississippi River Commission.

This modification of the original project was approved by the Secretary of W April 22, 1887.

The actual placing of the sills can only be done during low water. The latenes the season when the allotment became available and the project for its expendit approved, together with the large amount of preparation and plant required, r dered it impossible to do any actual construction on the sill dams during the l water season of 1886.

The preparatory work done in accordance with the approved projects has consis of a survey of the site of the proposed sills, the construction or purchase of all necessary plant, and in making arrangements for a supply of the necessary stone ballasting the sills.

On November 6, 1886, a survey party left New Orleans for the purpose of makin survey of the Atchafalaya in the vicinity of Simmsport, La., to obtain the ne sary data to determine the most favorable location for the proposed sills. T survey was most thorough and elaborate, and it is believed that all the data nec sary for the location of the proposed sills has been obtained. The field work w completed February 20, 1887. For details as to methods, etc., I refer to the repor Mr. W. J. Hardee, herewith.

Incidental to the survey, the cross-sections of the Atchafalaya between its head Bayou des Glaizes, made in November, 1883, were repeated. The following compa tive table gives the results:

Cross-sections of the Atchafalaya River between the mouth of the river and Simmsport

Number of section.	Area.				Hydraulic radius.			
	1883.	1887.	Increase.	Decrease.	1883.	1887.	Increase.	Decre
			Per cent.	*Per cent.*			*Per cent.*	*Per ce*
2	83,045	87,256	.048		61.7	64.0	.065	
4	33,269	38,206	.15		35.1	38.3	.10	
6	36,222	37,513	.034		44.7	43.5		
8	27,817	31,739	.12		38.0	36.4		
10	44,093	46,740	.056		38.5	47.9	.19	
12	45,768	52,399	.12		42.0	48.9	.14	
13	39,482	37,928		.043	45.9	41.4		

It will be noted that the enlargement of the Atchafalaya from November, 1883 February, 1887, has been very slight. It seems fair to assume that this is due to partial closure of the Tensas Front by levees. Appearances indicate that the in ence of the leveeing of the Tensas Basin on the Atchafalaya problem has been v great. It is possible that the further enlargement of the Atchafalaya might ce entirely when the Mississippi, during floods, is prevented from overflowing into Tensas Basin, provided the outlet capacity of Old River remained unchanged. T last could hardly happen, however, with the concentrated discharge that would t

lace through Old River, and I am therefore of the opinion that the levees on the Tensas Front should not be extended further down the river until one or more sills have been placed in the Atchafalaya.

On January 25, 1887, plans and specifications having been prepared, proposals for the construction of the six lowering-barges, provided in the project, were opened and contract awarded. Work on the barges was commenced immediately, and five of them were completed June 30, 1887. The remaining one of the six barges will be completed July 9, 1887.

Proposals for building the three general-service barges were opened April 9, and contract awarded. Good progress has been made on them, and they will probably be completed by July 15, the date specified in the contract.

Proposals for building three large ways barges were opened April 19, and contract awarded. They are generally similar to the lowering-barges, with the exception of the ways. They are to be completed August 15, 1887.

The approved project provided for the purchase of a tug to be used in connection with this work. The requirement was made known to steam-boat men and parties having tugs for sale. A number of offers of tugs with description were received, and such as were thought suitable for the work were examined. An offer of a tug, called the *John Orm No. 2*, was received from Paducah, Ky., and after inspection the boat was purchased for $6,555, this amount being $500 less than that estimated in the project. A crew was sent to Paducah, and the tug was utilized to tow the quarter-boats and pile-driver, borrowed from the first district, to the mouth of Red River. She arrived there on June 27. The tug was brought to New Orleans to assist in towing the plant of barges, etc., to the Atchafalaya, and also to have some slight necessary repairs made to her machinery. The following is her description:

(1) The hull was built at Paducah, Ky., at the end of the year 1884, and commencement of 1885, of well-seasoned Kentucky oak, and is now in sound and good condition; the length is 73 feet by the inspector's report; 75 feet on deck; the beam is 15 feet, and the depth is 8 feet 6 inches. The date of the first inspection is the 5th of March, 1885, and of the last the 29th of November, 1886. The gross tonnage measurement is 77.41, the deduction 20.48, leaving a net tonnage of 56.93.

(2) The boiler is of longitudinal multitubular form and was built in 1884 by James Reese & Co., of Pittsburgh, Pa. It is of steel, with twenty 6-inch cylinders, double riveted and drilled holes; it was new when put into the boat in March, 1885, and it was last inspected on the 29th of November, 1886, when a maximum steam pressure of 122 pounds was allowed. The usual steam pressure carried is from 80 to 90 pounds, and to maintain this the average consumption of coal has been about 65 bushels a day. The coal used has been mostly slack.

(3) The engine, which is 16 by 16 inches, was built in 1884 by the Novelty Machine Works of Evansville, Ind. It was new when it was placed in the boat. The shaft is of steel, 5 inches in diameter, with three brace-bearings, and the diameter of the wheel is 5 feet 9 inches. The boat is fitted with a No. 6 Rival pump made by McDonald, of Cincinnati, Ohio, which has a capacity of 22 gallons a minute; it also has the necessary syphons and an extra hand-pump on deck.

(4) The coal-bunkers hold 600 bushels, and when they are full the boat draws 6½ feet. It is fitted with a balance-rudder 5 feet high, 4½ feet behind, and 18 inches in front.

Information was received that stone for ballast suitable for the proposed sill work could be found in the States of Mississippi and Louisiana in quarries easily accessible to the work. An examination of the different localities was made in the early part of February, and specimens of the different quarries were obtained on the ground for examination and test. Stone weighing 150 pounds per cubic foot was found near Boyce Station on the Texas and Pacific Railway, about 80 miles from West Melville on the Atchafalaya. An agreement with the parties owning the quarries has been made, and the stone is to be delivered on the banks of the Atchafalaya at West Melville, from which point it will be transported on barges to the locality of the sills as required. By this arrangement the number of barges required is greatly reduced, and the expense of unloading the stone on the bank at the sills, reloading it and then placing it on the mattresses is avoided. Under the present arrangement two or more barge loads of stone will be brought up when required and unloaded directly on to the mattresses which are to be sunk.

Arrangements have been made to obtain three quarter-boats and a pile-driver from the first district, and should nothing unforeseen occur everything will be in readiness to commence work on the sills as soon as the river reaches a sufficiently low stage.

The amount expended in the execution of the approved project as modified to June 30, 1887, is $27,128.84.

The amount that can be profitably expended during the fiscal year ending June 30, 1889, is $200,000.

The work is in the collection district of New Orleans, which is the nearest port of entry.

COMMERCIAL STATISTICS.

All the river commerce of Red River, Bayous Macon and Tensas, Ouachita and Black rivers, the Atchafalaya, Bayous Courtableau and des Glaizes, together with numerous tributaries, and a large portion of the commerce of Bayou Teche, passes through Old River. The total value of the commerce to be benefited by the improvement is estimated at $40,000,000 annually.

FINANCIAL STATEMENT.

Improving the Mississippi River (no limit).

(a) Rectification of Red and Atchafalaya rivers:	
Act of August 5, 1886, allotment	$187,500.00
July 1, 1887, amount expended during the fiscal year ending June 30, 1887	27,128.84
July 1, 1887, balance available	160,371.16
(b) Mouth of Red River:	
July 1, 1886, amount available	4,364.43
August 19, 1886, amount alloted	15,000.00
Total	19,364.43
July 1, 1887, amount expended during the fiscal year, exclusive of outstanding liabilities, July 1, 1886	19,013.60
July 1, 1887, balance available	350.83

CONSTRUCTION AND REPAIR OF LEVEES.

The project of levee building adopted by the Commission has so far been simply to close the existing gaps in the lines already established by constructing levees as far as the funds allotted will permit with locations of reasonable permanence and grades equal to the adjacent levees. While proceeding under this plan the loss of levees by caving banks and their breaching by floods may be annually anticipated.

At the beginning of the fiscal year no work was in progress, owing to lack of funds. The levees built were generally in good condition. Some repairs were known to be necessary to the United States levees at Hard Times, Kempe, and to the Glasscock swamp portion of the Green's to Fairview Levee, all on the Tensas front. On the Atchafalaya Front the line of levees was continuous, except the Morganza Crevasse.

From the appropriation of Congress made in the act approved August 5, 1886, for improving Mississippi River, the Commission at its meeting September 20, 1886, allotted $40,000 to be applied to the building of Morganza Levee, the resolution being as follows:

"That the sum of $40,000 be applied to the building of Morganza Levee, provided the balance of the sum necessary to complete said levee be contributed by the State of Louisiana, and raised from other sources."

A project for the expenditure of this sum was called for, and was prepared and submitted by Major Raymond. This project was, briefly, as follows:

"That the United States district engineer be authorized to enter into an agreement with the contractor for the work to be done by the State of Louisiana and parish of Pointe Coupée. That the work of the United States shall commence when the work of the State and parish has been completed to the satisfaction of the district engineer. Payment shall be made upon the completion of the levee to the satisfaction of the United States district engineer. All work to be paid for by the United States shall be executed under the supervision and in accordance with the instructions of the United States district engineer. The agreement shall be subject to the approval of the Secretary of War."

This project was approved October 15, with the condition that the work done by the State authorities should be subject to inspection by the United States engineer officer in charge of the district.

In accordance with the approved project, an agreement was entered into with the State contractor to build the portion of the levee to be paid for by the United States, at the rate of 25 cents per cubic yard, and an inspector was placed at once upon the work being done by the State.

The construction of the levee was commenced October 13, 1886. Owing to the lateness of the season it was considered somewhat uncertain whether the levee could be completed before the high water of 1887, but, favored by dry weather, the work was pushed with great energy, and on January 29, 1887, the levee was reported completed. A careful final inspection was made, the work found to be satisfactory, and the levee was accepted. Since that time it has been tested by the moderate flood of 1887, and has shown no signs of weakness.

On September 20 and November 27, 1886, the Commission made allotments of funds, to be assigned by the Board of Engineer Officers on building and repair of levees, for the construction, repair, and maintenance of levees in the third and fourth districts.

With funds derived from this source repair work has been done on the United States levees at Hard Times, Kempe, and on the Glasscock Swamp portion of the Green's to Fairview Levee.

For details concerning levees I refer to the report of my assistant, Mr. H. S. Douglas, who has special supervision of levee work.

The gaps now existing in the lines of levees in the district are on the Tensas Front, and are as follows:

Diamond Island Bend, a gap about 50,000 feet long.

Bougere Crevasse, a gap about 23,400 feet long.

Black Hawk to Red River, a gap about 90,000 feet long.

At Deer Park, two short gaps.

A gap is seriously threatened at the United States Kempe Levee, where the bank is caving rapidly, and is now within a short distance of the embankment.

On the Atchafalaya Front the closure of the Morganza Crevasse makes the line of levees continuous from the mouth of Red River to the forts.

The commerce benefited by levees is all that of the Lower Mississippi River.

The work coming under the general appropriation for improving the Mississippi River from Cairo to the Head of the Passes, no separate appropriation is asked for.

FINANCIAL STATEMENT.

Improving Mississippi River (no limit).

(*a*) Levees on Atchafalaya Front:	
July 1, 1886, amount available	$511.35
October 5, 1886, amount allotted	40,000.00
Total	40,511.35
July 1, 1887, amount expended during the fiscal year, exclusive of outstanding liabilities July 1, 1886	40,511.35
(*b*) Levees on Tensas Front:	
July 1, 1886, amount available	1,413.72
November 20, 1886, amount allotted	11,100.00
Total	12,513.72
July 1, 1887, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1886	10,613.66
July 1, 1887, balance available	1,900.06
(*c*) Protection of levees:	
March 4, 1887, amount allotted	7,000.00
July 1, 1887, amount expended	503.82
July 1, 1887, amount available	6,496.18

SURVEY OF THE MORGANZA REACH.

The survey of the Morganza Reach was called for by a resolution of the Commission of November 26, 1886.

The object of the survey was to obtain preliminary data from which to note the effect of the closure of Morganza Crevasse upon the channel of the river in the vicinity. For this purpose fifteen cross-sections of the reach have been carefully made, permanently marked and referred to the Memphis datum, so that they can be repeated at some future date for comparison.

The survey was only intended to establish data for future comparison, but as the cross-sections were nearly coincident with those made in 1883, under the direction of

the Commission, I have had these sections plotted on the same sheet with those of the present survey, and the following comparative table of areas and hydraulic radii prepared:

Increase and decrease in area and in hydraulic radius, cross-sections of Morganza Reach, Mississippi River.

Cross-section.	Area.			Hydraulic radius.		
	1883.	1887.	Increase +; decrease —.	1883.	1887.	Increase +; decrease —.
			Per cent.			*Per cent.*
1	112,186	113,697	+.013	43.5	44.3	+.018
2	114,583	121,890	+.063	37.6	37.7	+.003
3	118,958	99,906	—.160	67.7	48.6	[illegible]
4	110,812	106,811	—.031	64.8	58.4	—.098
5	129,770	109,702	—.154	55.0	49.2	—.105
6	108,590	97,277	—.101	42.4	40.8	[illegible]
7	104,633	103,529	—.010	29.5	33.6	[illegible]
8	110,970	93,093	—.161	37.2	33.1	[illegible]
9	92,183	89,658	—.027	37.4	41.0	[illegible]
10	109,869	80,193	—.270	50.6	40.1	[illegible]
11	96,967	81,169	—.162	47.7	40.4	—.153
12	127,352	109,733	—.138	58.1	48.5	—.166
13	131,315	115,445	—.120	47.4	40.0	—.156
14	121,401	89,819	—.260	35.7	24.2	—.322
15	102,130	85,737	—.160	42.3	34.9	—.174

The Morganza Crevasse has been open for thirteen years, nine of which were prior to the survey of 1883. It would seem that during this time the channel of the river, at least so far as it was affected by the crevasse, would have attained a state of equilibrium, but the table does not indicate that it had. Of the fifteen cross-sections, Nos. 1, 2, 3, 4, 5, 6, and 7 were above the main crevasse channel, and Nos. 8, 9, 10, 11, 12, 13, 14, and 15 below.

On the sections from 1 to 7, above the crevasse, there is an average decrease in area of 6,454 square feet, and an average decrease in hydraulic radius of .039 per cent. On the sections from 8 to 15, below the crevasse, the average decrease in area is 18,417 square feet, and the average decrease in hydraulic radius is .150 per cent. The decrease is nearly four times greater below the crevasse than above.

The table covers a period of forty-seven months, from February, 1883, to January, 1887, during which time four floods had passed.

The necessary preliminary data being now at hand, it is hoped that the effect of this crevasse on the river channel will soon be definitely and positively established.

The report of Assistant Engineer H. S. Douglas on the survey is appended.

FINANCIAL STATEMENT.

Survey of Mississippi River.

Survey of the Morganza Reach:

December 15, 1886, allotment	$600
July 1, 1887, amount expended during fiscal year	600

IMPROVEMENT OF THE MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

No work has been done in this vicinity, owing to the lack of funds.

The approved project contemplates the protection of the caving banks by means of submerged sloping-spurs placed at intervals to be determined as the work progresses, but assumed for estimate of cost at 1,000 feet. The estimated cost is $600,000.

To prevent the flow of water across the neck of land between Giles and Cowpen bends, and the anticipated destruction of the harbors of Natchez and Vidalia by a cut-off, it is proposed to construct a levee at an estimated cost of $100,000. This makes the total estimates $700,000.

The amount which can be profitably expended during the fiscal year ending June 30, 1889, is $250,000, for the purchase of the necessary plant, the construction of the levee, and the commencement of dike work.

COMMERCIAL STATISTICS.

Exact information is not obtainable, but it is estimated that there is received annually at Natchez, Miss., about 40,000 tons of provisions, groceries, machinery, 7,000 tons cotton seed, and 25,000 tons coal. The shipments are about 40,000 bales of cotton and 4,000 tons oil products. About 1,200 steamers arrive and depart.

At Vidalia, La., the receipts were about 8,000 tons produce, provisions, and machinery, and the shipments about 10,000 bales cotton and 2,000 tons cotton seed, but a railroad recently completed to Trinity, La., has added materially to the commerce of Vidalia.

The work is in the collection district of New Orleans, which is the nearest port of entry.

FINANCIAL STATEMENT.

July 1, 1886, amount available	$1,000.65
July 1, 1887, amount expended during the fiscal year ending June 30, 1887, exclusive of outstanding liabilities July 1, 1886	175.00
July 1, 1887, amount available	825.65

Approximate value of plant belonging to the United States and used upon the improvement of Mississippi River, fourth district.

Class of property.	Approximate value July 1, 1887.	Class of property.	Approximate value July 1, 1887.
Steamer *General Newton*	$13,000	1 floating storehouse	$1,400
Steam tug *John Orm No. 2*	6,600	Tools and appliances	3,600
Steam-tug *Tilda*	5,000	Office furniture	700
Steam-launch *Ruby*	3,000	Surveying instruments	1,500
Steam-launch *Alaska*	3,000	Miscellaneous	1,800
2 quarter-boats	3,000		
26 barges	51,550	Total	94,150

List of civilian engineers employed on works of river and harbor improvement in charge of Capt. Dan C. Kingman, Corps of Engineers, to June 30, 1887, inclusive, under the river and harbor appropriation act approved August 5, 1886.

Name and place of residence.	Months employed.	Compensation per month.	Where employed.	Work on which employed.
H. S. Douglas, New Orleans	1½	$140	New Orleans	New Orleans Harbor, levees, mouth of Red River.
Do	10½	175	....do	Levees.
W. G. Price, New Orleans	10½	155	....do	Mouth of Red River and New Orleans Harbor.

DAN C. KINGMAN,
Captain of Engineers.

F 1.

REPORT OF ASSISTANT ENGINEER PRICE ON WORK IN NEW ORLEANS HARBOR.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., April 7, 1887.

SIR: I have the honor to submit the following report on the work of improving the harbor at New Orleans, La.:

On October 6, 1886, the work of repairing the plant was begun. As no work had been done since December 1, 1884, the necessary repairs were quite extensive.

The work of constructing submerged Spur No. 1 at Gouldsboro was commenced on November 29, and the spur was completed on January 6, 1887. Construction of Spur No. 6 was begun the next day, and it was finished on February 3.

It was intended to finish Spur No. 5, which was partially constructed in 1884, and three cribs had been built for that purpose. The plant was placed in position at that spur on February 7, but owing to the great quantity of heavy drift running, it was found to be impracticable to sink the cribs at that place. A portion of the plant was then moved up in front of the Texas and Pacific Railroad incline, and the three cribs remaining on hand were sunk so as to carpet the bank in front of the incline from a low-water depth of 35 feet down to a depth of 75 feet. The up-stream ends of the cribs lapped on the down-stream edge of the mattress in Spur No. 3, and they extend 140 feet down-stream. Work was then suspended.

The work was delayed very much by the slow delivery of willow brush, and the cost of the spurs was thereby considerably increased. The method of constructing and sinking the mattress and cribs was the same as in 1884, except that the cribs were built and launched from ways on a float, instead of on ways on the bank. The float had just enough buoyancy to support the crib timbers and the first layer of willow brush. This method was found to be cheaper and better than the old one.

Owing to the swift current during the work on Spur No. 6, I was obliged to devise a new method for locating the exact position of each crib as it was lowered, so as to make them rest in their correct positions when sunk. Three or four No. 12 wires were attached along the center line of the crib to be sunk, and as the crib was lowered each one in succession was hauled taut by a small capstan in a skiff, with a pull of 500 pounds. With a transit on shore I could determine when the wire was vertical, and thus locate the position of the crib with reference to the center line of the spur.

The average cost of the spurs built this season, exclusive of cost of plant, was $10,460, but this includes rock at a cost of $4.11 per cubic yard. We have used less than half as much rock for a spur as was used in 1884. I think all the cribs, except the top one in a spur, could be ballasted safely with clay in sacks, and this would greatly reduce the cost of the work.

A survey of the Gouldsboro bend was made during the month of October, 1886, and this survey compared with those of 1884 and 1885 shows that there has been very little change in the spurs, or in the bank and bed of the river between them. They are apparently holding the bank in the same position as when they were put down, except that there has been a cave a short distance above Spur No. 5. But Spur No. 4 has not been built, and Spur No. 5 is only partly completed, and as the bank at this point was very steep a cave was to be expected.

The velocity of the water at high stage of the river is much less along shore than it was before the spurs were built.

Very respectfully, your obedient servant,

W. G. PRICE,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers.

F 2.

REPORT OF ASSISTANT ENGINEER DOUGLAS ON WORK AT THE MOUTH OF RED RIVER.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 30, 1887.

CAPTAIN: I have the honor to submit the following report on the work of maintaining a low-water channel between the Mississippi and Red and Atchafalaya rivers during the fall of 1886:

At the end of the fiscal year, June 30, 1886, no funds were available for this work, except sufficient to care for property. The importance of commencing before the river had reached too low a stage was well known. The headquarters of the office having been temporarily transferred to New York City during the sickly season in New Orleans, I was directed by Maj. C. W. Raymond, the officer then in charge, to keep him informed from the best information attainable of the condition of Old River.

On August 1 I reported "8 feet on the bar at the mouth, 7 feet near Ash Cabin, 4½ feet on the crossing, and thence to the Atchafalaya, 18 feet; that the river was falling at the rate of 6 inches per day; that it was reported that there had been a general filling up of the deep holes existing in previous years between the mouth and Ash Cabin, and that this was likely to add considerably to the difficulty of maintaining navigation by the scraping process, as there would be no way of disposing of the material that might be scraped off the shoals."

On August 6 I was directed to hold myself in readiness for commencing work in Old River, and on the 9th I was ordered to begin operations as soon as possible.

The stern-wheel steamer *General Newton* was in very bad condition, having been very much strained by the work of previous years, and no money had been available for her repair. It was thought that it would be hardly safe to take her out. However, a suitable boat could not be chartered in New Orleans, and time did not permit of going elsewhere. Accordingly the *Newton* was hastily and temporarily strengthened and repaired where she was conspicuously weak.

Preparations were pushed as rapidly as possible, and on August 12 the *Newton*, with coal barge in tow, left for the mouth of Red River, where she arrived on the morning of the 14th.

Owing to the lateness of the season and the low stage of the river, it was thought that the chance of successful work was rather more than dubious. A careful examination of Old River was made on the 14th, and although a least depth of 30 inches was found it was thought that there was a chance of maintaining navigation.

The *Newton* proceeded at once to the Government landing above Natchez, Miss., took on board the scraper which had been left there, and with the two quarter-boats and the steam-launch *Ruby* in tow, returned to the mouth of Red River on the morning of August 16. The derrick for raising and lowering the scraper, which hung from the bow of the boat, was rigged up as soon as possible, and on August 17 the work of scraping on the bar at the mouth was commenced. On that day there was a channel with a depth of 3¼ feet over the bar. On the 20th the depth had been increased to 5½ feet by the scraping process.

Scraping on the bar was continued until the 27th, when it was ascertained that all the mud had been removed and only sand remained. On this the scraper made but little impression, and scraping was discontinued. The *Newton* was then anchored on the bar and an attempt made to wash out the sand with her wheel. This was partially successful, but as the boat could only be secured in one position and the bar was 600 feet across, some other means had to be devised to carry the washing process clear across the bar. Accordingly clusters of piles, about 50 feet apart, were driven in a row along the edge of the proposed channel, from deep water in the Mississippi River to comparatively deep water in Old River.

The steamer *Osceola* arrived on September 13, to relieve the *Newton*, and the scraper and attachments were transferred to her. On September 17 the clusters of piles had all been driven across the bar, and it was determined to give the washing-out process a thorough trial. Authority for the repair of the *Newton* had not yet been received, so she was retained on the work. On the morning of the 17th the two boats were placed in position on the outer edge of the bar. Their position and method of operations were as follows: The *Osceola* laid in next the cluster piling, to which she was firmly lashed, her bow pointing out into the Mississippi and her wheel being just on the edge of the bar. The *Newton* laid alongside the *Osceola*, to which she was securely fastened, so that her wheel was immediately opposite to and on line with the *Osceola's*. The current was setting from the Mississippi into Old River and the wheels of both boats were started with the current, which was accelerated to such an extent that all the sand for about 50 feet astern was washed away. When this had been done, the two boats, still lashed together, were dropped back about 50 feet along the piling and the wheels again started. This was continued until the boats had worked entirely across the bar and into deep water inside. On the morning of the 17th soundings on the bar gave a channel with a depth of only 3½ feet. On the evening of the 17th, after the boats had washed the channel across the bar, soundings showed a channel with a least depth of 6 feet, and there were numerous holes with a depth of 10 feet. The two boats continued to work successfully in this manner until September 23, when the *Newton* returned to New Orleans for repairs. The *Osceola* continued the washing process, occasionally using the scraper where clay stratas were developed, until the sliding banks closed navigation in the "Gut" and there was no object in keeping water on the bar. The channel washed by one boat is, of course, not so wide, nor is it so deep as when two boats are used.

On August 20, shortly after scraping on the bar was commenced, three small barges and a pile-driver, kindly loaned by Captain Rossell, from the third district, arrived at the mouth of Red River.

On August 22 a force of laborers was organized, and they commenced cutting brush and piles for dike construction. The location of the first dike in the "Gut" near section R, having been determined on, the pile-driver commenced driving piles on the 24th, and the first dike was completed on the 28th. In the meanwhile the river continuing to fall, a dry sand-bar made its appearance at the mouth, making two channels at that place. It was noticed that a portion of the Mississippi water entering Old River at the upper channel returned through the lower channel. As it was absolutely necessary to the success of the dike work to have all the water possible pass through Old River to the Atchafalaya it was decided to close the lower or return channel. A dike or dam about 350 feet long was built from the main shore below the mouth out to the dry bar, entirely closing this channel. The construction of other dikes in Old River was then undertaken, and at all wide places clear through to the

Atchafalaya dikes were built to concentrate the current and deepen the channel Wherever the bottom was composed of sand or soft mud the effect of the dikes was to cut out the channel very rapidly, opposite and for some distance below. Where the bottom was composed of hard clay the dikes had but little effect.

All the dikes and the dam were built in the following manner: First, two rows of light piles were driven on the line of the proposed dike. The piles were spaced about 3 feet apart. The space between the rows was about 3 feet, and this space was filled in with willow brush, the first courses being laid diagonally, with the brushy tops outside the piles to prevent undercutting. After the space between the two rows of piles had been filled up above the water-surface, bags filled with sand were placed on top to weight the brush down and retain it in position. Such dikes are only temporary, but they serve the purpose for which they are built very effectually during low-water season.

On August 29 the first sliding or sloughing of the banks took place between the "Dead Tree" and the "Crossing." No injury to the channel from this cause was, however, observed until September 22, when lumps and ridges commenced to develop between Dikes 4 and 6, near Ash Cabin. From this time on mud lumps and ridges continued to rise in the channel with great rapidity. Frequently in a few hours the channel would be entirely changed or totally obstructed from this cause. To add to the difficulties, the current, which since the commencement of work had been running strongly from the Mississippi toward the Atchafalaya, became slack, caused by a rise from Red River. On October 20 an attempt was made to blow up the mud ridges near Ash Cabin with Hercules powder. The trial was made on a ridge which extended clear across the channel. It was about 5 feet wide and there was only about 1 foot of water on the crest. Some of the powder was placed in a hole about 5 feet deep, and some was laid on top of the ridge and covered with a sack of clay. The latter method was found to give the best results. The effect of the explosion was to flatten out the ridge up and down stream. It broke up the material and made it much softer, so that a good current would have washed it away. A depth of 3 feet over the ridge was obtained by this means, but the clay continued to squeeze up from the bottom, so that in the end we had a ridge 50 feet wide instead of 5 feet. Had there been a swift current to remove the material loosened by the blast, the results might have been better.

Mud springs developed, from which an apparently inexhaustible supply of mud and sand continually rose. The mud lumps and ridges continued to come up with increasing rapidity, and notwithstanding every effort the channel closed to navigation on October 28. From October 21 to 31 the river fell 2.2 feet, reading on the latter date 2.7 on the Red River Landing gauge.

There being no prospect of further successful work until the river rose, the plant was laid up and the force discharged.

On November 21 a rise from Red River and tributaries caused a strong current into the Mississippi and gave sufficient water for navigation. The material scoured out of Old River by the current caused the bar at the mouth to shoal, and the *Osceola* recommenced washing and scraping on the 24th. The *Newton* having been repaired, returned to the mouth of Red River on November 27, and relieved the *Osceola*. Both the Mississippi and Red rivers continued to rise, rendering further work unnecessary. All piles that might prove high-water obstructions were pulled, and the steamer *Osceola*, the pile-driver, and the three barges were returned to the third district on December 9, 1886. This closed the season's work.

As to the results accomplished, the following statement will give an idea: On August 16, prior to the commencement of work, when the Red River Landing gauge read 11.6 and the Barbre's gauge 8.3, there was a navigable channel through Old River with a least depth of 30 inches. This depth and better was maintained until October 26. On that date the Red River Landing gauge read 3.7, a fall of 7.9, and the Barbre's gauge 3.7, a fall of 5.6. In other words, the bottom of Old River, at numerous points, would have been dry, and from 3 to 5¼ feet above the water-surface, but for the work done by the United States. It is reasonably certain that navigation was maintained for at least two months, when otherwise Old River would have been entirely closed.

The following is a summary of the work done:

Number of mooring piles driven	37
Number of piles driven in dikes	1,383
Number of cords brush placed in dikes	424
Number of sand-bags filled and placed on dikes	6,474
Total length of dikes built ... feet	2,609
Approximate amount of material removed from the channel of Old River, cubic yards	284,000

I have been acquainted with the low-water channel of Old River since 1879, and almost every year have seen the work of maintaining navigation assume some new phase. What was then a succession of deep pools and shoals, bordered by extensive

mud-flats, has assumed a great many of the characteristics of a high-water outlet bayou. The mud-flats have become defined banks, with a growth of willows on them. The pools have filled up, and the cross-section has become regular and almost semicircular between the defined banks. Instead of two or three low-water shoals, the bar at the mouth, the "Gut," and the "Crossing," there is now a continuous shoal from the Mississippi to the head of the Atchafalaya. The nearly total closure of the Tensas Front by levees, thus preventing the escape at high water of the Mississippi into the Tensas Basin, has apparently checked the enlargement of the Atchafalaya, but the problem, so far as the commercial interests are concerned, of maintaining low-water navigation between the Mississippi and Red and Atchafalaya is still unsolved.

So far as the present temporary methods are concerned, by beginning the work of scraping out the mud at Ash Cabin about the time the river fell to a 20-foot stage on the Red River Landing gauge, there would be a much greater probability of the channel being kept open.

Mr. W. G. Price, assistant engineer, was associated with me upon the work, and rendered the most efficient assistance, both in originating and carrying out the various methods by which it was hoped to maintain navigation.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. DAN. C. KINGMAN,
Corps of Engineers.

F 3.

REPORT OF SURVEYOR HARDEE ON THE SURVEY OF THE ATCHAFALAYA RIVER.

NEW ORLEANS, *La., March* 1, 1887.

SIR: I have the honor to submit the following report of the Atchafalaya River survey and the method pursued.

The portion of the river embraced in the survey lies immediately in front of the town of Simmsport, La., and extends from the mouth of Bayou des Glaizes to a point down-stream about 9,000 feet.

As a basis, a carefully chained traverse line was run between the above points on both banks of the river, the stations on which are permanently designated by iron tubes 2 inches in diameter and driven to a depth of from 2½ to 3 feet in the ground, extending above about 1½ feet.

Cross-sections of the river were made at right angles to the line of current at intervals of not more than 100 feet, with the initial points of same resting on the west bank traverse. All sections were extended from levee to levee, and on every fifth section the lines were produced 500 feet back of both levees to show the slope of ground surface. By means of the level the bank elevations were acquired. Soundings were made on sections not more than 30 feet apart and located with one transit stationed at the end of a base line, thrown at right angles to the line of cross-section. Distances to soundings measured by scale of natural tangents. All soundings are reduced to the zero of Barbre's Landing gauge. Elevations referred to the same plane.

On the completion of the cross-sections the entire area of the river embraced in the survey was sounded by means of float soundings. Soundings were located by the intersection of two transits positioned at traverse stations.

In all about 13,000 soundings were taken, many of which by reason of their too close proximity were rejected, but as will be shown by the chart sufficient depths were acquired to show a good, clear profile of the bottom and designate any existing irregularities.

All topography within a distance of about 700 feet of the river bank was measured with transit and stadia, and also enough of Bayou des Glaizes to define its position and entrance into the Atchafalaya.

The notes of the above survey have been compiled and remain on file in this office.

Very respectfully,

W. J. HARDEE,
Surveyor.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. Army, New Orleans, La.

F 4.

REPORT OF ASSISTANT ENGINEER DOUGLAS ON CONSTRUCTION AND REPAIR OF LEVEES.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 30, 1887.

SIR: I have the honor to submit the following report on the construction and repair of levees, fourth district, for the fiscal year ending June 30, 1887.

At date of last annual report, June 30, 1886, no work was in progress owing to lack of funds. The levees previously built were generally in good condition. It was known that some repair work was necessary to the United States levees at Hard Times, Kempe, and from Green's to Fairview. The gaps existing in the lines of levees were as follows: On the Tensas Front, Diamond Island Bend, Bougere Crevasse, and Black Hawk to Red River. On the Atchafalaya Front, Morganza Crevasse.

The Morganza Crevasse, which the present levee closes, is located on the right bank of the river in the Morganza Bend, about 10 miles above the town of Bayou Sara. During the flood of 1874 the Morganza Levee was swept away, and for 10 years the crevasse remained open, permitting the escape of an enormous volume of water from the river during floods, and overflowing a large area of country. In 1883–'84 the levee was rebuilt at the expense of the State, but it had scarcely been completed when it was again swept away by the flood of 1884.

This disaster gave rise to a popular impression that it was almost impossible to build a line of levee at this point that would stand. Some special difficulties undoubtedly did exist, as the line for a levee necessarily crosses over ridges and irregular hillocks of loose material deposited by the river during floods, and was thus liable to pass over buried masses of drift logs or brush.

In order to avoid these sources of danger to the present levee extraordinary precautions were taken. Work was commenced October 13, 1886, and was prosecuted in the following manner: After the surface had been thoroughly cleared, a muck ditch of varying width and depth was dug. This ditch was excavated clear through all material deposited since 1874, down to the original buckshot soil, which was at one time cultivated land. In some cases this ditch had a depth of 16 feet. If in the course of the excavation logs or rack heaps were discovered, they were dug out and removed beyond the base of the levee and the ditch filled in with clay. As an additional precaution, long iron rods were used to probe the ground and detect the presence of logs or rack heaps. After the foregoing had been done the embankment was commenced.

The dimensions of the embankment were as follows: Width of crown, 10 feet; side slopes, 3 to 1, and at some special places 4 to 1. The levee was strengthened with a banquette or terrace 20 feet wide on the land side wherever the levee was more than 8 feet high. This gives a base of 150 feet for a height of 20 feet. The extreme net fill was 24 feet. The total length of the present Morganza Levee is 9,250 feet; its grade is about 2 feet above the flood of 1882, and it contains 270,523 cubic yards of earth.

The weather during the progress of the work was exceptionally good, but three days being lost from rain, and embankment construction was pushed with great energy, as indeed was necessary, owing to the lateness of the season when work was commenced.

On January 29, 1887, the levee having been reported completed, a careful inspection was made under your personal direction, and the levee was found to be satisfactory and was accepted.

The State authorities retained a small force upon the levee during the past high-water season, as a measure of precaution and to repair wave-wash or other injury to the embankment. It is, however, gratifying to state that notwithstanding the new and unsettled condition of the levee it has shown no signs of weakness.

The repair work at Hard Times, Kempe, and Glasscock levees was of such a character that it was impracticable to measure it and pay by the cubic yard for work done, so bids for furnishing laborers with the necessary equipment were asked and very reasonable terms secured.

At Hard Times Levee the old sinking place at the crossing of Lake St. Joseph had again sunk slightly, and at several points where the line of the levee crosses sloughs it had cracked and slid or sloughed off on the sides. A growth of young trees had started on the slopes, and at some places the embankment was deeply gullied by rain-wash.

A force was put to work on December 27, 1886, to repair the sloughing and sinking places, clear off the levee, and fill the gullies. The work was completed April 7, except at one point where the embankment continues to crack and slide off on the sides as fast as fresh earth is put on top. Some additional work may be necessary at this point before next high water.

At Kempe Levee the crossing of Potter's Lake had again cracked and sunk. A force was put to work December 27, 1886, to build up the embankment. This work was

completed February 14, 1887. Kempe Levee is now seriously threatened by the rapid caving of the river bank in front, and it is thought that the embankment will be breached from this cause before the flood of 1888. A break at this point will be very serious and permit of the escape of an enormous volume of water from the river.

Glasscock Levee is that portion of the United States Green's to Fairview levee passing through the Glasscock Swamp. During the high water of 1886 the levee was reported to be in a dangerous condition, and a break was only prevented by the exertions of parties living in the neighborhood. This weakness, being unexpected and apparently unaccountable, gave rise to rumors of defective construction; that logs, barrels, etc., had been placed in the embankment. Upon the decline of the flood the true cause was discovered. The borrow pits dug in the construction of the levee, being in buck-shot soil, which is non-absorbent, remained filled with water the year round, and in these pits a colony of beavers had located. They had made their dens or houses in the levee embankment itself, and had tunneled almost through at several points. An inspection was made and one place discovered (the point at which a break had been threatened) where the beavers had made a hole entirely through the embankment. The levee being thickly overgrown with young trees, briars, and weeds, it was impossible to detect all the damage that had been done.

A force was put to work December 21, 1886, and the first work undertaken was to clear the levee of trees, briars, etc., and in doing so six separate places were discovered where the embankment had been burrowed into by the beavers. A ditch about 2,000 feet long was then dug to drain the borrow pits into the river and deprive the beavers of their harbor. This ditch was twice closed by the beavers, but ultimately the greater portion of the water was drained off. The work of cutting out the beaver holes in the levee was then commenced. The main passage-way to the den generally started at the outer edge of the levee berme, in the borrow pits, and concealed by the water. This passage-way would have several branches leading into the den in the center of the levee. The den was generally located under the land slope, and was from three to four stories in height, the first being about on a level with the natural surface of the ground, and the uppermost one nearly up to the crown of the levee. The injury to the levee could hardly have been greater, as it was reduced to a mere shell and was liable to a collapse at any time. In repairing the damage it was found necessary to virtually rebuild the levee at several points for a length of from 25 to 30 feet. Eight beavers were killed by the workmen during the time they were engaged on the repairs. On March 3, 1887, the levee having been placed in a safe condition, work was suspended on account of high water. As soon as the river falls it will be necessary to deepen the ditch already dug and dig another at a point further up the river.

So far as can be learned, this is the first instance in this district where levee embankments have been injured by beavers. Had a crevasse occurred at this locality, it would very likely have been attributed to faulty construction of the levee or to the boring of crawfish, and not to the true cause, the beavers.

One portion of the United States Green's to Fairview levee passes through the Deer Park Plantation. At this point the river bank is caving very rapidly, and provision for a new levee has been made by the Commission.

The levees generally throughout the district are in good condition. They have not been placed under any severe strain during the past season, as the flood of 1887 was a very moderate one.

The line of levees is now continuous on the Tensas Front from the head of the district to Bougere's Landing, in Concordia Parish, with the exception of the Diamond Island Bend Gap. Between Bougere's Landing and the mouth of Red or Old River there are only isolated pieces of levee on the high ground, the principal gaps being Bougere's Crevasse and from Black Hawk Landing to Red River.

On the Atchafalaya Front the levees are now continuous from Red River to the forts.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers.

F 5.

REPORT OF ASSISTANT ENGINEER DOUGLAS ON SURVEY OF MORGANZA REACH.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 1, 1887.

SIR: I have the honor to submit the following report on the survey of the Morganza Reach, Mississippi River:

The survey was made in accordance with a resolution of the Commission passed at their meeting November 26, 1886, that a set of cross-sections, not exceeding 15 in

number, and extending 3 or 4 miles above and below Morganza, be taken on lines well marked for future reference.

The party engaged in making the survey for the proposed sill-dams in the Atchafalaya was temporarily transferred to the Morganza Reach. Mr. W. J. Hardee was in immediate charge of this party, which was thoroughly organized and equipped, and he is entitled to great credit, no time being lost, and the work being done both accurately and quickly.

The field work of the survey was commenced January 12, 1887, under my personal direction, and was completed January 25, 1887. The actual working time, exclusive of time lost from bad weather, was eleven and one-quarter days, during which time the following was accomplished:

Length of traverse line run, 20.23 miles; length of line chained, comprising measurements to establish initial points of sections, bank distances on sections, and base-lines for locating soundings, 11.16 miles; length of level lines run to establish datum at the different sections, and to prolong sections from water's edge on either bank, 16.8 miles; number of soundings taken and located with two instruments on cross-sections, 748.

The method of operations was as follows: On arrival in the reach a general reconnoissance was made and the location of the fifteen cross-sections decided on. In locating the sections an endeavor was made to have them cross the river on lines previously sounded by the Commission in the general survey of this portion of the river, made in February, 1883.

A line of levels was run on the right bank the full length of the reach, and bench-marks established at each section. All levels were referred to the Memphis datum. Two and sometimes three iron tubes were driven and located on the line of each section to permanently mark its position and direction. Base-lines for locating soundings were measured at each section. Considerable clearing was necessary to open vistas for the level lines on the sections. A transit and stadia traverse line was run on the right bank the full length of the reach, to connect the sections and locate the shore-line and levees. This was all incidental work to the actual sounding of the cross-sections, and the most of it was done at times when the wind was too strong for accurate sounding.

In sounding the cross-sections the following method was observed: The line of the section was ranged off on either bank with flags, as a guide for the soundings. Two transits were then set up, one on either end of the base-line previously measured. One end of the base was always on the section line. Levels were then taken from the bench-mark previously established, on a measured line from the zero point of the section to the water's edge, and the elevation of the water-surface determined. The lead line was then tested and soundings commenced. To secure plumb soundings in the swift current, the launch was run above the section line, the lead thrown, and the launch and lead allowed to drift together down on to the ranged line, at the moment of crossing which the sounding was taken. Commencing at the right bank the launch was gradually worked across the river, taking about twenty-five soundings, each of which was located, regardless of the ranged line, by two transits. When the left bank was reached a flag was set up at the water's edge and located. The section was then prolonged, by means of measurement and levels, from the flag up to the high-water bank. The launch then commenced the return trip to the right bank, taking about twenty-five more soundings, thus duplicating the section and checking any error of the leadsman. Upon the completion of the section the lead line was again tested, and the party transferred to the next section, where the same routine was followed. About fifty soundings were taken on each section, and in plotting the work but few errors were discovered.

I do not think any difficulty will be experienced in repeating the sections, as the iron tubes marking them are not likely to be destroyed.

The field work of the survey has been plotted, and accompanying this report is a tracing of the chart of Morganza Reach, showing locations of cross-sections and permanent marks; also comparative cross-sections from surveys of February, 1883, and January, 1887.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. DAN. C. KINGMAN,
Corps of Engineers.

APPENDIX Z Z.

REPORTS OF THE MISSOURI RIVER COMMISSION.

Z Z 1.

ANNUAL REPORT OF THE MISSOURI RIVER COMMISSION, 1886.

MISSOURI RIVER COMMISSION,
OFFICE OF THE PRESIDENT, 1415 WASHINGTON AVENUE,
Saint Louis, Mo., November 17, 1886.

SIR: The Missouri River Commission beg leave to submit herewith their annual report upon the operations in their charge for the fiscal year ending June 30, 1886.

SURVEYS.

The survey of the Missouri River, which has been in progress for the last eight years, has been carried on by the Commission mainly with funds allotted from the appropriation for improvement, there having been only a small balance remaining from the last specific appropriation for this work.

At the date of the last annual report a surveying party was *en route* for Fort Benton, Montana. On July 4 they began work at this latter point and by October 1 had progressed down-stream a distance of 240 miles to Trover's Point, where operations were closed for the season. The work of this party was preliminary, and consisted of secondary triangulation, levels, and the establishment of permanent bench-marks. During the winter the triangulation work was adjusted and all computations made, and the base line of the previous year's work at Glasgow, Mo., was measured. It had been intended, during the current season, to complete the work near Fort Benton by filling in the topography and

hydrography, but no funds being available for the purpose, the Commission have decided to continue on the lower river the secondary triangulation and establishment of permanent bench-marks, which work it is hoped may be completed between Fort Leavenworth and Glasgow, a distance of 192 miles, during the present season. There will then remain, to complete the work, triangulation from Fort Leavenworth, Kansas, to Trover's Point, Montana, 1,501 miles; topography and hydrography from Fort Pierre, Dakota, to Fort Benton, Montana, 1,100 miles; establishment of permanent bench-marks from Fort Leavenworth, Kansas, to Trover's Point, Montana, and from Boonville, Mo., to the mouth of the river, a total distance of 1,908 miles. The total estimated cost of this much-needed work is $165,000, and at least $50,000 should be devoted to it annually till it is completed.

In the office of the Commission, besides the work incidental to the surveys mentioned, progress has been made on the compilation and tabulation of physical data already collected. Eighteen water-gauges have been maintained during the year. The records of all known gauges have been collected and tabulated. They have been, so far as possible, reduced to a common datum plane, the Saint Louis city directrix, and prepared for publication.

For details of this work, see report of the Secretary of the Commission, Appendix A.

CONSTRUCTION.

IMPROVING MISSOURI RIVER FROM SIOUX CITY, IOWA, TO FORT BENTON, MONTANA.

Work has been confined to the upper portion of the river above Carroll, where rapids and rocks mainly obstruct navigation. At Grand Island dams were constructed, as also at Dauphin's Rapids and below Fort Benton, the object in all cases being either to increase the navigable depth over the rapids by damming the water back or to sweep away shoals of sand by concentrating the force of the current. These works have been successful. The new plant ordered for the work has been completed.

From the close of field work in the fall of 1885 to the end of the fiscal year nothing has been done beyond caring for the public property, the appropriation being practically exhausted.

Under recent legislation this work has passed out of the hands of the Commission.

For details of work done, see report of Capt. James B. Quinn, Corps of Engineers, United States Army, Appendix B.

IMPROVING MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY, IOWA.

In this district work has been carried on in the vicinity of Saint Joseph, Mo., and Kansas City, Mo. At the first place, the object in view was to extend and complete certain works of bank protection constructed in previous years to prevent the formation of a threatened cut-off, while at Kansas City the work was the commencement of a thorough, systematic, and continuous improvement of the lower portion of the river. In the last annual report of the Commission the methods employed were described at length, together with details of the progress made in the early part of the season.

Saint Joseph, Missouri.—After the subsidence of the June rise work at this place was resumed. From July 15 to 20th, 435 cubic yards of rock were placed on those portions of the Elwood revetment repaired in the

spring, and on July 24 work was resumed on the revetment of the left bank in Bonton Bend. This work progressed steadily till October 8, when the mattress work had been carried down-stream a distance of 9,725 feet and partially covered with stone. The boats employed on the work were then hauled out of water for safety during the winter, and were launched again in the spring when the ice had ceased running. Work was then resumed, and the work of placing the rock covering on the upper portion of the bank was completed. In carrying out this work there were used 7,372 cords of brush and 12,605 cubic yards of rock. In grading the banks above water 83,394 cubic yards of earth were removed by the use of a water-jet.

During the season some 2 miles of badly caving bank was substantially revetted and the caving at once stopped. Below the limits of the work, however, the caving has gone on at the same rate as before. To check this and complete the work the revetment must be extended 10,000 feet farther, which it is expected will be done during the spring of 1887. There will still remain the extension of the Elwood revetment to Belmont, about 18,000 feet, which cannot be undertaken till further appropriations are made.

For details of the work attention is invited to the report of Assistant S. Waters Fox, in local charge, Appendix Q.

Kansas City, Missouri.—Work at this point consisted in revetting the caving banks in Kaw and Quindaro Bends. Work on Kaw Bend was begun in the spring, and 3,000 feet had been revetted at date of last report. By the end of July all the plant available had arrived on the ground, and on August 3 work was resumed in Kaw Bend. The first 1,300 feet of mattress constructed had a total width of 90 feet from the top of the graded bank, 60 feet being beyond the line of low water. The remaining 6,400 feet had a total width of 110 feet, of which 75 feet was beyond the low-water line. The upper bank was sloped to an average grade of 3½ to 1 by hydraulic graders.

The completion, early in October, of this 7,700 feet of revetment (10,700 during the season), effected a junction with the work of 1882, and completed the protection of the upper portion of Kaw Bend. The working parties were then transferred to Quindaro Bend, on the opposite side of the river. Work here was begun on September 7, and the mattress work was finished October 27. The Quindaro Bend revetment is 9,760 feet long and 135 feet wide, 75 feet being below low-water line. Five mattress-boats were employed, and the maximum force of men aggregated 822. Owing to the failure of the contractor for rock to fulfill the conditions of his contract much trouble and delay were experienced. It was finally found necessary to haul most of the stone needed in wagons, and the work of placing it was carried on during the winter and spring. The Kaw Bend work was finally completed on January 2 and the Quindaro work at the end of April. In the execution of this work 14,159 cords of brush were consumed and 34,608 cubic yards of rock. In grading the banks 75,419 cubic yards of earth were removed by the hydraulic graders. The whole work was of the most thorough and satisfactory character, and promises to afford a complete protection against further encroachments of the river. During the month of December all the boats used on the work were hauled out on the bank for safe-keeping, except the tow-boats, graders, and some other pieces, 28 in all, which were sent into winter quarters at Bushberg, near Saint Louis.

When the ice broke up in the spring a gorge formed in the bend in front of Kansas City, and the water backed up above it, forced its way

through the sand-bar to the north of Pest Island. This channel ke on enlarging during the season till it finally carried the bulk of t water. Unfortunately this channel led under one of the fixed spans the bridge, and as the bar between it and the bend was too shoal f boats to cross, the bridge during the whole low-water season became t head of navigation. Nothing could be done in the matter; the balan remaining in the hands of the Commission being insufficient to defr the cost of the extensive rectification works required.

Funds from the new appropriation became available too late to ena the Commission to resume work this fall, but all needful preparatio will be made to begin as soon as the river is clear of ice in the spri It is expected that the revetment of the right bank below Kansas Ci known as the East Bottom, will be completed, as also the revetment the left bank, in Sharp's Bend, below Randolph. This work, togeth with the rectification works in Lower Kaw Bend and at Pest Isla will probably exhaust the current appropriation before the end of fiscal year.

There will still remain to be done in this vicinity revetment work Parkville and Little Platte Bends to secure the head of the work, a revetment at Wyandotte and Harlem, when the rectification wo have accomplished their object. Continuing down the river fr Sharp's Bend, Big Blue and Wayne City bends require revetment w rectification works and revetment of the left bank opposite the mo of Big Blue River. This, with sufficient funds available, can be co pleted during the fiscal year ending June 30, 1888, and will carry finished work to Liberty, Mo., 30 miles from the starting point.

For fuller details of this work, see report of Assistant Samuel H. Yonge, in local charge, Appendix D.

OPERATIONS FOR THE COMING SEASON.

The peculiar wording of the act making appropriation for the improvement of the Lower Missouri River, approved August 5, 1886, has caused the Commission much embarrassment in deciding as to the precise wishes of Congress in the matter. The act appropriates the sum of $375,000 for continuing the improvement of the Missouri River, including necessary work at Omaha, Atchison, Saint Joseph, Fort Leavenworth Reservation, Arrow Rock, Kansas City, Plattsmouth, Brownville, and Nebraska City, under the direction of the Secretary of War, in accordance with plans and estimates to be furnished by the Missouri River Commission.

The Commission in previous reports have outlined their plan for the improvement of the navigation of the river, which consists essentially in contracting the width of the stream to comparative uniformity, and in fixing the location and direction of the channel by protecting all banks exposed to the erosive action of the current. This work, to have any value, must be thorough and continuous, and after due consideration the Commission decided to begin the work in the vicinity of Kansas City and to carry it on down-stream from that point to the mouth of the river. This plan was approved by the Secretary of War, and work in prosecution thereof has been in active progress during the past season. To continue this work the Commission in their last annual report recommended an appropriation of $1,000,000. The current act, while materially reducing this estimate, directs that "necessary work" shall also be done at nine specified localities according to plans and estimates to be presented by the Missouri River Commission. What

this necessary work consists in is not stated, but the Commission infer that the protection of land exposed to the encroachments of the river is what was intended. The Commission have no certain knowledge of what the extent of such work in each specified locality may be, but from old reports and maps they infer that at each locality the expenditure of from $200,000 to $500,000 will certainly be required. Moreover the experience of the last ten years has amply demonstrated that it is rarely possible to do such work in annual installments. The whole work must be carried through to completion in one season, as otherwise the incomplete work done in one year will in all probability be destroyed before an opportunity is afforded for its resumption. To carry on work simultaneously at all the places designated in the act would require from $1,000,000 to $1,500,000, besides $300,000 or $400,000 more for the plant needed in its execution. The plant already in the hands of the Commission is not more than adequate for work at one locality, the detail last year of a portion of it to Saint Joseph having been of decided detriment to the main work at Kansas City. As there were, therefore, neither adequate funds nor sufficient plant to carry out the apparent intention of Congress, it seemed obvious to the Commission that, in order that anything should be accomplished, some selection of localities was absolutely necessary. At two of the places designated, Kansas City and Saint Joseph, work had been in progress last year and plans for its further prosecution had been prepared, while the plant required was already on the ground. As these two places are second to none on the river in commercial importance, and as Kansas City, moreover, is in the line of the general improvement, it seemed obvious to the Commission that if any selection were allowable these were the proper points to select. They accordingly recommended to the Secretary of War an allotment of $260,000 for Kansas City and of $75,000 for Saint Joseph. They also recommended that $10,000 be allotted for surveys at the seven other designated localities, the balance of the appropriation, $30,000, being set aside for the purchase of additional plant. On October 28 these recommendations received the approval of the Secretary of War, but owing to the lateness of the season no field work of any magnitude can be done before spring.

The special surveys have, however, been taken in hand, and as soon as they are completed special reports with plans and estimates will be submitted for the information and action of Congress.

RECOMMENDATIONS.

The Commission renew their recommendation that at least $1,000,000 be appropriated for continuing the improvment of the river, in addition to any sums which Congress may see fit to devote to work at special localities. With a less sum than this it will be many years before the work will cover a sufficient extent of river to enable a proper estimate to be formed as to its cost and its value to the country. No engineering difficulty has as yet presented itself to suggest any doubt as to the possibility of carrying it to successful completion.

For continuing the survey of the Missouri River, for the examinations and observations required in a thorough study of the problem confided to them, and for salaries, traveling and office expenses, the Commission recommend an appropriation of $150,000. They also renew their previous recommendation that the $15,000 appropriated for a survey of the Missouri River above the Missouri River Falls, at Fort Benton, be made available for the general survey of the river.

The recommendations of the Commission for the year ending June 30, 1888, are recapitulated as follows:

(1) Appropriation for the improvement of Missouri River from its mouth to Sioux City	$1,000,000 00
(2) Appropriation for surveys and examinations	120,000 00
(3) Appropriation for office and traveling expenses and salaries of Commissioners	30,000 00
(4) Reappropriation for general survey of Missouri River of the item of $15,000 appropriated in the act of July 5, 1884, for survey of the river above the falls	15,000 00

Money statement.

Available July 1, 1885, and received since to June 30, 1886:			
Appropriation for survey of Missouri River from its mouth to Fort Benton, Montana, act of August 2, 1882			$8,500 00
Appropriation for improving Missouri from its mouth to Sioux City, Iowa, act of July 5, 1884			340,928 80
Appropriation for improving Missouri River from Soux City, Iowa, to Fort Benton, Montana, act of July 5, 1884			50,763 37
Appropriation for survey of Missouri River above Missouri River Falls, at Fort Benton, act of July 5, 1884			15,000 00
From sales of fuel to officers			181 46
Total			415,373 63
Expended from July 1, 1885, to June 30, 1886, exclusive of outstanding liabilities, July 1, 1885:			
By first district officers		$243,606 19	
By second district officer		32,938 09	
By the Secretary of the Commission		39,963 88	
Total		316,508 16	
Outstanding liabilities July 1, 1886:			
Of first district officer	$3,072 07		
Of second district officer	1,091 38		
Of the Secretary of the Commission	1,655 32		
		5,818 77	
			322,326 93
Balance available July 1, 1886			93,046 70

Respectfully submitted.

CHARLES R. SUTER,
Major of Engineers, U. S. A.,
President Missouri River Commission.
A. MACKENZIE,
Major of Engineers, U. S. A.
O. H. ERNST,
Major of Engineers, U. S. A.
GARLAND C. BROADHEAD.
WILLIAM J. BROATCH.

HON. WM. C. ENDICOTT,
Secretary of War,
(Through the Chief of Engineers, U. S. A.)

Financial statement from July 1, 1885, *to June* 30, 1886.

Work.	Resources.				Expenditures.			Unexpended balances June 30, 1886.
	Unexpended balance July 1, 1885, of appropriation, act of August 2, 1882.	Unexpended balances July 1, 1885, of appropriations, act of July 5, 1884.		Received, sales of fuel to officers.	Since July 1, 1885.		Total to June 30, 1886.	
		Allotments.	Unallotted.		Paid.	Unpaid liabilities, June 30, 1886.		
In charge of Secretary: Survey of Missouri River from its mouth to Fort Benton, Montana	$8,500	....	......	......	$5,913 87	$80 00	$5,993 87	$2,506 03
From its mouth to Sioux City, Iowa.								
Office and traveling expenses and salaries of Commission	......	$9,404 19	......	$131 22	8,334 91	438 82	8,773 73	761 68
Surveys and permanent bench-marks	......	1,326 00	......	......	823 28	....	823 28	502 72
Care of plant, river gauges, physical data	......	10,436 58	......	......	7,905 85	1,090 40	8,996 25	1,440 33
Tow-boat	......	24,150 00	......	......	250 00	....	250 00	23,900 00
In charge of Major Suter, Corps of Engineers, to May 31, and of Major Livermore, Corps of Engineers, since June 1, 1886:								
Kansas City	......	*222,821 78	......	......	173,979 09	2,020 31	175,999 40	46,822 38
Saint Joseph	......	72,790 25	......	......	69,627 10	1,051 76	70,678 86	2,111 39
From Sioux City, Iowa, to Fort Benton, Mont.								
In charge of Captain Quinn, Corps of Engineers:								
Office and inspection expenses, district officer	......	†4,033 92	......	......	3,388 58	645 34	4,033 92	....
Work below Fort Benton	......	21,673 21	......	......	21,478 17	195 04	21,673 21	....
Purchase and repair of plant	......	8,322 34	......	......	8,071 34	251 00	8,322 34	....
In charge of Secretary:								
Office and Commission expenses	......	5,000 00	......	50 24	5,002 57	46 10	5,048 67	1 57
Surveys	......	11,733 90	......	......	11,733 90	....	11,733 90	....
Above Fort Benton.								
Survey above falls	......	....	$15,000	......	....	....	....	15,000 00
Total	8,500	391,692 17	15,000	181 46	316,508 16	5,818 77	322,326 93	93,046 70

*$2,000 transferred to Saint Joseph allotment.
†$1,500 transferred to work below Fort Benton; $251 transferred to purchase and repair of plant.

Financial statement from July 1, 1886, to October 31, 1886.

Work.	Resources.				Expenditures and transfers.			
	Amounts available July 1, 1886.	Transferred from other allotments.*	Allotments.†	From sales of fuel.	Amounts expended exclusive of outstanding liabilities July 1, 1886.	Outstanding liabilities November 1, 1886.	Transferred to other allotments.	Amounts available November 1, 1886.
In charge of Secretary.								
Survey of Missouri River from its mouth to Fort Benton, Montana	$2,506 63				$1,692 53	$255 11		$558 99
Improving Missouri River from its mouth to Sioux City, Iowa:								
Office and traveling expenses and salaries of Commission	761 68	$25,000		$50 24	2,805 35	1,258 39		21,748 18
Surveys and permanent bench-marks	502 72	23,000			4,536 73	3,705 07		15,260 92
Care of plant, river-gauges, physical data	1,440 33	12,000			2,365 25	720 00		10,355 08
Tow-boat	22,900 00						$22,900	
Special surveys			$10,000					10,000 00
Improving Missouri River from Sioux City, Iowa, to Fort Benton, Montana:								
Office and Commission expenses	1 57				1 57			
In charge of Maj. W. R. Livermore, Corps of Engineers.								
Improving Missouri River from its mouth to Sioux City, Iowa:								
Kansas City	46,822 86		200,000	29 24	10,556 15	33,859 20	36,100	226,336 [illegible]
Saint Joseph	2,111 39		75,000		2,054 49	10,508 51		64,548 39
Construction of plant			30,000					30,000 00
Unallotted.								
Survey of the Missouri River above the Missouri River Falls, at Fort Benton	16,000 00							15,000 00
Total	93,046 70	60,000	375,000	79 48	24,002 07	50,366 28	60,000	383,757 [illegible]

* Appropriation, act of July 5, 1884.

† Appropriation, act of August 5, 1886.

Abstract of proposals opened by Capt. J. H. Willard, Corps of Engineers, U. S. A., for Maj. Charles R. Suter, Corps of Engineers, U. S. A., at Saint Louis, Mo., at 12 o'clock m. July* 15, 1885, *for furnishing and delivering on Government barges* 15,000 *cubic yards or more of riprap for improvement of Missouri River in the vicinity of Saint Joseph, Mo.*

Number.	Names and addresses of bidders.	Landings where riprap is to be delivered.	Distance from Saint Joseph water-works. Miles up-stream.	Distance from Saint Joseph water-works. Miles down-stream.	Quantity.	Price per cubic yard.	Charge for towage per cubic yard.†	Comparative price per cubic yard.	Amount.
					Cu. yds.	*Cents.*	*Cents.*	*Cents.*	
1‡	Andrew Sheridan, Saint Joseph, Mo.	Saint Joseph water-works.	....	....	15,000	75	....	....	$11,250 00
2	G. T. Nelles, Leavenworth, Kans.	Four miles below Saint Joseph water-works.	....	4	15,000	72½	2	74½	11,175 00
3	William J. Hobson, Saint Joseph, Mo.	Mouth of the Nodaway River.	11	....	15,000	69	2¾	71¾	10,762 50
4	Henry W. Dunn..	One mile above Saint Joseph water-works.	1	....	15,000	80	¼	80¼	12,037 50

*Major Suter confined to his house by sickness.
†The towage charge added for comparing proposals is at the rate of ¼ of 1 cent per cubic yard for towing up-stream, and ½ of 1 cent per cubic yard per mile for towing down-stream, distance measured from Saint Joseph water-works.
‡Informal.

Abstract of contracts for improvement of Missouri River from its mouth to Sioux City, Iowa, in force during the fiscal year ending June 30, 1886.

Contractors' names and residences.	Subject of contract.	Date of contract.	Riprap-stone per cubic yard.
		1885.	*Cents.*
T. M. Hackett & Son, Atchison, Kans.*.	50,000 cubic yards riprap stone, for use on work at and near Kansas City, Mo.	July 13	69½
William J. Hobson, Saint Joseph, Mo.†..	15,000 cubic yards riprap stone, for use on work at and near Saint Joseph, Mo.	Aug. 4	69

*Contract annulled October 24, 1885. †Contract closed May 18, 1886.

APPENDIX A.

ANNUAL REPORT OF SECRETARY.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., June 30, 1886.

SIR: I have the honor to forward herewith annual report of the Secretary of the Commission, with accompanying appendices, drawings, and photographs; also itemized statements of expenditures by the Secretary, and financial statement of the Commission for the past fiscal year.

Very respectfully, your obedient servant,

THEO. A. BINGHAM,
First Lieutenant of Engineers, U. S. A.,
Secretary Missouri River Commission.

Maj. CHARLES R. SEUTR,
Corps of Engineers, U. S. A.
President Missouri River Commission.

ADDITIONAL SURVEYS AND ESTABLISHMENT OF PERMANENT BENCH-MARKS BELOW SIOUX CITY. (SECONDARY TRIANGULATION.)

No work has been done since last annual report, except to measure a base-line at Glasgow, which was done in November, 1885.

Full details of this measurement are given in my report to you dated March 6, 1886, copy herewith. (Appendix A 1.)

The field work covers the river as far up as Glasgow. The notes are complete and awaiting computation, for which the balance available is not sufficient by $1,200.

The report above referred to contains itemized statement of expenditures in the field and a photograph of one of the triangulation stations ready for work.

ADDITIONAL SURVEYS AND ESTABLISHMENT OF PERMANENT BENCH-MARKS ABOVE SIOUX CITY. (SECONDARY TRIANGULATION.)

At date of last annual report the party had not arrived at Fort Benton. They arrived there July 4, and worked down the river, 240 miles, to Trover's Point, Montana, where field work for the season ended October 1. Since that time the adjustment and computation of the triangulation have been under way and were completed with the close of the fiscal year.

Tabulation of final results and plot of the triangulation are appended. (Appendix A 2.)

For full details as to the field work, base measurements, levelings, &c., reference is respectfully made to my report to you dated March 1, 1886 (copy herewith, marked Appendix A 3).

Attention is called to the remarkably good results obtained in the measurement of secondary bases with our steel tape. Comparisons were made during the year of our standard tape with others belonging to Prof. J. B. Johnson, of Washington University, and Prof. D. C. Humphreys, of Washington and Lee University. In March, 1886, Professor Johnson, who is publishing a text-book on "Surveying," was, at his request, furnished with an abstract of the results obtained under the Commission in measuring secondary bases with a steel-tape. This was done in view of the fact that otherwise it would probably be a year or more before these interesting results were published.

Before computation the triangulation was adjusted by the method of least squares. The adjustment has been rigid, with one or two exceptions, where the highest refinement would not have materially altered the result and would have entailed an expense not admissible at present. The number of combined angles entering the adjustments was 388, with corrections as follows:

Between 0″ and 1″	270
Between 1″ and 2″	102
Between 2″ and 3″.08	16

The computation was through 90 triangles, from the following data:

Base.	Length.	Observed azimuth.	Elevation.
	Meter.	° ′ ″	′
Benton	3008.06	E. base to W. 73 01 05.78	2900
Trover's Point	2959.84	W. base to E. 251 29 12.23	2344

Bases were reduced to sea level. Latitude and longitude of E. base at Benton, as transferred from flag-staff (determined during Northern Boundary Survey) were: Latitude, 47° 50′ 26″ north, longitude 110° 40′ 03″ west from Greenwich.

Clarke's values were adopted in computing. The general method followed in the computation was that given in Merriman's Method of Least Squares, the solution being made by the use of correlates. This does not differ materially from the method given in Clarke's Geodesy for a simple quadrilateral, or from the method used under General Comstock on the Mississippi River. The final discrepancies are:

	Log. meters.	Azimuth.
		° ′ ″
Trover's Point base, measured	3.4712689	251 29 10.18
Computed from Benton	3.4713670	12.23
Difference	.0000981	2.05

The difference in azimuth is less than the range (4″.5) of three nights' observations on Polaris at Benton. The difference in length of base is 1 in 4,400, or 1′.2 in one mile. The following is of interest in this connection:

MEMORANDA OF DISCREPANCIES.

Secondary triangulation, Mississippi River Commission.

Report for—	From—	To—	Distance.	No. of △	Discrepancies. Ratio.	Per mile.	Azimuth.
			Miles.			*Feet.*	″
1881, p. 29	Cairo	Cottonwood	120	122	1 in 2,650	2.0	8.00
	Cottonwood	Memphis	120	103	1,830	2.8	0.59
1882, p. 63	Chester	Cairo	......	30	6,000	0.88	21.80
	Adams	Helena	......	4	5,700	0.92	17.00
	Helena	Greenville	......	219	1,000	5.28	26.6
	....do	Concordia	......	87	1,100	4.8	....

Cottonwood base (see Mss. Rept. 15—A. b., p. 9). Computed from Cairo and Memphis, 1m.48 = 4′.75 per mile = 1 in 1,111. Distance Cairo to Memphis, 230 miles, 225 triangles.

Common line (Mss. Rept. 441—B. C., p. b. and 161—B. K., p. 17). Computed from Helena and Memphis, 0m.58 = 2′ per mile = 1 in 2,640. Distance 75 miles by river.

Common line (Mss. Rept. 1,009—B. K., p. 8). Computed from Cairo and Chester, 1m.39 = 0′.92 per mile = 1 in 5,740, 39 triangles.

So that the discrepancy in computed length of base is within range, though unexpectedly large. It was equivalent to determining the length of a line 175 miles distant from the measured base through 90 triangles.

The discrepancy was distributed through the 39 parts of which the system is made up by assigning $\frac{1}{39}$ to the first part, $\frac{2}{39}$ to the second part, and so on.

Angles as adjusted were not changed, so that the lower line of any quadrilateral as tabulated will be found to be less by 25 in the seventh place of logarithms than as computed from the upper line, giving a local discrepancy of about $\frac{1}{175000}$. It was thought best not to incur the expense of greater accuracy for the present.

The observed and computed values for latitude of west base, Trover's Point, differ by 23″.7. But the latter (47° 37′ 34″.1) is adopted until future accurate determinations of both latitude and longitude can be made.

Mr. O. B. Wheeler, who has been in immediate charge of the triangulation, commends his assistants and is himself worthy of appreciation by the Commission for faithful and able work. His report is appended (Appendix A 2), which, with this, is intended as a final report on the Benton-Trover's Point division of the triangulation.

The allotment for the survey of the Missouri River is almost exhausted, there being on hand June 30, 1886, an available balance of only $2,506.63. Although full value has been received for money already spent yet this important work, from its great extent, is still far from complete. About 1,711 miles have still to be covered by the triangulation (Glasgow, Mo., to Trover's Point, Montana), and about 1,100 miles have still to be surveyed for topography and hydrography. Fifty thousand dollars can be profitably expended in a season, one half by each of the two parties; and it is not economical to put either party in the field with an allotment of less than $25,000.

There are several reasons why the survey should be immediately and continuously pushed to completion. It is the necessary preliminary to the adoption of a plan for the improvement of the upper river, and can be done for at least 25 per cent. less money if continuously and energetically pushed, because large expenditures in repairs and training of party will thus be saved. But the most important reason is that the Commission have now available a corps of skillful assistants, already familiar with this particular work and river, whose services will not be available unless secured immediately. Others, perhaps not as capable and certainly having no familiarity with the work, will have to be depended on if the survey is dropped now and resumed at a later date.

The cost of the field work in Montana, as previously reported, was $110 per mile of river covered. Although this amount is not excessive, considering the remoteness of the work done, involving large bills for transportation and the purchase of supplies at the proverbially high prices of that section, still it is believed that it can be much reduced in future, owing to two considerations:

First. The entire party were engaged from their departure from Bismarck, and the

survey steamer on which they went up was heavily loaded with supplies. Her power being very insufficient for work in the upper river, the trip to Benton was a prolonged one, during which the party were drawing pay and no work was being done. It was necessary to pay the party from their arrival at Bismarck, but it is believed that in future better arrangements can be made to get them to their work.

Second. It has been found not to be advisable to have the pioneering party dependent on the main party for daily accommodations. Their necessary return every night to the only steamer along (on which the main force was quartered) prevented them from keeping ahead of the others. As the pioneer party must do its work before the others can follow, much time was thus lost for lack of means to keep them in the advance. It is proposed in future to provide separate transportation for this party, so that they can keep well in the lead and only have occasionally to return to the main party for supplies or purposes of inspection by the chief of triangulation, who is the chief of the pioneers. Careful consideration and computation show that, for this purpose, in addition to the steamer carrying the main party, a small swift steam-launch is needed, and that the additional expense thereby incurred will be more than compensated by the increased distance covered during the working season and reduced cost per mile of work done.

The cost of the computation on the Benton-Trover's Point triangulation was $2,321.66, or $9.673 per mile, making the total cost from beginning of field work to completion of computation $120.00 per mile.

It is believed that in future this can be reduced more than 25 per cent.

PRESERVATION AND OBSERVATION OF GAUGES AND COLLECTION AND COMPILATION OF PHYSICAL DATA.

The compilation described in detail in last Annual Report has been brought very near completion, as will be seen by reference to table in Appendix A 4.

The study of the data has been begun, and has mainly, so far, been confined to gauge relations and discharge-gauge relations. Good progress has been made. For details as to work done and an outline of methods and work proposed reference is respectfully made to Appendix A 4. Mr. J. A. Seddon, who has been in charge during the year, is entitled to credit for faithfulness and ability.

Seven thousand five hundred dollars can be profitably expended in this department during the current fiscal year.

GAUGES.

The seventeen regular gauges reported last year have been kept up and read twice daily during the year.

The records have been carefully watched by plotting and other means, and are complete and reliable. All seventeen have been twice inspected (reset and repaired when necessary) during the year, at a total cost of $725.

There is great difficulty in establishing permanent and satisfactory gauges at reasonable cost on the Missouri River. Even those on bridge piers have not been altogether satisfactory. But a pattern of bridge gauge has been found which works well and which has been placed on all the bridges crossing the river. The number of gauge observers is thereby increased by two, but as soon as sufficient comparisons of gauge readings (which should extend through at least one high-water season) have been made it is the intention to discontinue several of the present unsatisfactory gauges.

The pattern of bridge gauge adopted is a 16 to 20 pound sash weight at the end of a $\frac{1}{8}$-inch best Swedish iron wire cord running over a 12-inch sheave and having a turn-buckle adjuster for changes in length. Drawing herewith (sketch) shows details and method of use. Full details are given in Mr. Blaisdell's report.

Mr. A. H. Blaisdell's report on last gauge inspection (hereto appended as Appendix A 5) sets forth clearly the present state and future requirements of this indispensable branch of physical data work. Parsimony in this kind of work is more unwise even than extravagance, because records to be worth anything must be accurate, and gauge readings cannot be accurate without, first, good gauges, and, second, intelligent and reliable observers, and both cost money. I therefore urge the allotment of $1,500 for construction and repair of gauges this fall, and of $3,500 for their care and maintenance during the coming fiscal year.

The complete records of all United States Engineer gauges observed on the Missouri River to January 1, 1886, have been arranged, stereotyped, and an edition of 300 is being printed (Appendix A 6.)

Arrangements have been made for obtaining the railroad gauge record at Bismarck, Dak., and also a monthly cross-section of the river there.

LEVELS.

In connection with the survey of the Missouri River, question arose as to the reliability of the elevations determined in past years; because the instruments used had been wye levels with New York rods, whereas the so-called precise leveling of the Mississippi River Commission had been done with Kern instruments and self-reading rods. The Coast and Geodetic Survey people, who are engaged upon a transcontinental line of levels, have advanced as far west of Saint Louis as Etlah, Mo., a station on the Missouri Pacific Railroad.

For nearly 20 miles (from South Point to Etlah) their line lies along the right bank of the Missouri River, where there are many United States Engineer bench-marks. The instruments used by them do not differ materially from those used by the Mississippi River Commission, so a party was sent into the field during February for two objects:

(1) By connecting the United States Engineer and Coast Survey bench-marks to get a check on our own elevations.

(2) To determine how closely to a line of "precise" levels a line can be run with a wye level.

A report of the information obtained was submitted to you under date of April 1. The conclusion therein reached was that there is every reason to abide by the elevations along the Missouri as at present determined. For details reference is respectfully made to said report (hereto appended as Appendix A 7).

This discussion is not yet fully complete, owing to lack of funds for farther field investigation, which it is estimated will cost $800.

TOW-BOAT.

The drawings have all been completed and blue printed. The specifications are drawn up and and ready for the printer.

A model of the hull has been made. Nothing further has been done since May, 1885.

COMMERCE.

By resolution of the Commission of December 11, 1885, the Secretary was directed to "procure statistics as complete as possible of the commerce of the Missouri River." This report was submitted to the President of the Commission June 30, 1886, and is herewith as Appendix A 8.

EXPENDITURES.

SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO FORT BENTON, MONTANA.

[Act passed August 2, 1882.]

Amount available of above appropriation July 1, 1885			$8,500 00
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:			
Wages	$5,297 67		
Traveling expenses	113 45		
Subsistence stores	66 34		
Transportation of employés	55 16		
Paper	20 75		
Hauling out steamer Missouri	350 00		
Repairing instrument	10 00		
		$5,913 37	
Unpaid liabilities June 30, 1886		80 00	
Amount expended during fiscal year			5,993 37
Amount available July 1, 1886			2,506 63

OFFICE EXPENSES, TRAVELING EXPENSES, AND SALARIES OF COMMISSION.

Amount available of above allotment July 1, 1885		$9,404 19	
Received from sales of fuel to officers		131 22	
Unpaid liabilities June 30, 1885		197 85	
			$9,733 26
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:			
Wages	$6,275 05		
Mileage	357 68		
Fuel	373 08		
Transportation of employés	25 00		
Traveling expenses	219 35		
Stationery	244 10		
Sundries	83 61		
Ice	24 72		
Office rent	600 00		
Office furniture	84 00		
Water tax	10 00		
Telephone	50 00		
Gas	15 30		
Awnings	16 75		
Typewriter	85 00		
Lumber	69 12		
		8,532 76	
Unpaid liabilities June 30, 1886		438 82	
Amount expended during fiscal year			8,971 58
Amount available July 1, 1886			761 68

ADDITIONAL SURVEYS AND ESTABLISHMENT OF PERMANENT BENCH-MARKS BELOW SIOUX CITY.

Amount available of above allotment July 1, 1885	$1,326 00	
Unpaid liabilities June 30, 1885	323 07	
		$1,649 07
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:		
Wages	791 58	
Pipe	291 25	
Iron rings and wire	7 77	
Transportation of instruments	3 75	
Privilege of felling trees	52 00	
Amount expended during fiscal year		1,146 35
Amount available July 1, 1886		502 72

PRESERVATION AND OBSERVATION OF GAUGES, AND COLLECTION AND COMPILATION OF PHYSICAL DATA.

Amount available of above allotment July 1, 1885		$10,436 58	
Unpaid liabilities June 30, 1885		60 00	
			$10,496 58
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:			
Wages	$7,317 50		
Traveling expenses	445 24		
Rock	35 00		
Rods	51 10		
Stationery	24 95		
Sundries	16 01		
Transportation of employés	10 00		
Wire	3 25		
Paper	37 50		
Repairing instruments	10 00		
Material and labor	15 30		
		7,965 85	
Unpaid liabilities June 30, 1886		1,090 40	
Amount expended during fiscal year			9,056 25
Amount available July 1, 1886			1,440 33

PURCHASE OF TOW-BOAT.

Amount available of above allotment July 1, 1885		$24,150 00
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:		
Wages	$250 00	
Amount expended during fiscal year		250 00
Amount available July 1, 1886		23,900 00

OFFICE EXPENSES AND EXPENSES OF COMMISSION.

[Sioux City, Iowa, to Fort Benton, Montana.]

Amount available of above allotment July 1, 1885		$5,000 00	
Received from sales of fuel to officers		50 24	
			$5,050 24
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:			
Wages	$2,110 81		
Mileage	876 16		
Transportation of employés	193 55		
Traveling expenses	327 00		
Rent of rooms	5 00		
Telegrams	9 43		
Fuel	1,049 34		
Stationery	33 64		
Sundries	57 04		
Gas	5 60		
Office rent	300 00		
Telephone	25 00		
Water tax	10 00		
		5,002 57	
Unpaid liabilities June 30, 1886		46 10	
Amount expended during fiscal year			5,048 67
Amount available July 1, 1886			1 57

SURVEYS BETWEEN FORT BENTON, MONTANA, AND SIOUX CITY, IOWA.

Amount available of above allotment July 1, 1885	$11,733 90	
Unpaid liabilities June 30, 1885	3,584 96	
		$15,318 86
Itemized expenditures from July 1, 1885, to June 30, 1886, both dates inclusive:		
Wages	$12,174 34	
Traveling expenses	200 90	
Subsistence stores	1,157 00	
Paper	1 70	
Fuel	1,247 25	
Stationery	23 65	
Transportation of instruments	359 90	
Lumber	15 25	
Sundries	138 87	
Amount expended during fiscal year		15,318 86

APPENDIX A 1.

REPORT OF LIEUTENANT THEODORE A. BINGHAM, CORPS OF ENGINEERS, SECRETARY OF COMMISSION.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., March 6, 1886.

SIR: I have the honor to submit herewith extracts from the records of this office relative to secondary triangulation along the Missouri River during the winter of 1884-'85.

Work began November 12, 1884, at Glasgow, Mo., and ended at Tavern Rock, Mo., March 30, 1885, a distance of 176 miles.

Sixty-nine triangulation stations were occupied determining 129 triangles and 35 quadrilaterals.

The system depends on a base line determined at Glasgow, in November, 1885, and on the Coast Survey station at Tavern Rock, with which connection was made.

Instruments used and methods of work and reduction were the same as described in detail in my report of work in Montana, dated March 1, 1885.

The Glasgow base was measured twice. The difference between the two measurements was 0′.166 giving a mean length of 7923′.32. The probable error of this mean is ±0′.056, or one in 140,000. But because the conditions of light and temperature were more nearly constant and alike during the first part of the first measurement and the second part of the second these two parts have been combined for the final result.

The result thus obtained is 7923′.344. A complete record of the measurement is given in Appendix A 1*b*.

One photograph is appended showing the arrangement of a triangulation station.

In Appendix A of the annual report of the Missouri River Commission for 1885 is reported the work of establishing permanent level bench-marks done during the same winter of 1884.

Table of itemized expenditures during the working season is appended.

Very respectfully, your obedient servant,

THEO. A. BINGHAM,
First Lieutenant Engineers, Secretary Missouri River Commission.

Maj. C. R. SUTER,
Corps of Engineers, U. S. A., President Missouri River Commission.

Allotment: additional surveys and establishment of permanent bench-marks below Sioux City, Iowa.

[Itemized expenditures for working season—November 12, 1884, to May 13, 1885.]

On what account.	1884. November.	1884. December.	1885. January.	1885. February.	1885. March.	1885. April.	1885. May.	Paid since to March 1, 1886.	Total.
Pay-rolls	$1,861 23	$3,811 24	$1,359 92	$1,664 50	$3,199 93	$1,047 40	$929 95	$598 75	$14,472 92
Subsistence stores	467 21	755 60	1 05			19 45			1,243 31
Bench-marks	57 90	48 25	700 35		2,657 16	1,572 50			5,036 16
Station-markers			3 80			3 25			7 05
Traveling expenses	162 75	80 30	56 60	28 50	40 35	36 80	19 60		374 90
Transportation of instruments		23 55				5 50	2 50	3 75	35 30
Wagons, and repairs of same	181 00	13 20	25 85				6 25		226 30
Note-books	26 00								26 00
Lumber	241 28	34 13		84 40					359 81
Oakum	55 50								55 50
Cloth	33 59		35			8 20		2 17	44 31
Targets and spoons			7 [illegible]			39 19			46 44
Wire and rings		2 80	9 65		25			4 69	17 39
Paints, oils, &c	65 06								65 06
Medicines	12 15								12 15
Sundries	44 41	2 98	10	4 60	1 10			3 48	56 67
Tools			18 35	25 75		6 00			50 10
Spokes, hinges, bolts and hasps	10 50	1 00							11 50
Nails and spikes	40 23	9 82			4 30	5 25			59 60
Lanterns and oil	4 90	10 92		2 75					18 57
Stoves and shovels	40 50	21 05							61 55
Jack screws					1 00				1 00
Rope	1 28	4 20							5 48
Mates' and steward' supplies	26 48	6 00				25			32 73
Pipe, bolts, cutting and drilling						928 90		291 25	1,220 15
Fuel						21 00			21 00
Repairs of instruments	6 25								6 25
Privilege of felling trees						20 80		96 40	117 20
Total	3,338 22	4,775 04	2,183 27	1,810 50	5,904 09	3,714 49	958 30	1,000 49	23,684 40

APPENDIX A 1a.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., November 12, 1885.

SIR: In accordance with your instructions, I have the honor to make the following report on the year's field work on the triangulation of the Missouri River.

A year ago to-day I reported at this office to receive instructions in regard to organizing parties for carrying on a secondary triangulation of the river.

Tertiary triangulation had previously been carried from Pierre, Dak., to the mouth of the river, in years 1878 to 1882, and a photolithographic topographical map published. Also the construction parties had from time to time made tertiary triangulation surveys of a portion of the same river, the principal one being the "low-water survey of 1882," extending from the vicinity of Saint Joseph to Boonville.

Maps of the upper river depend on meanders, with estimated distances, corrected at points by astronomical observations.

In the tertiary triangulation surveys the station markings were of necessity on the bottom lands, and not of a permanent character, and it was desirable that a more permanently marked and more accurate triangulation should be made, where the bases should be measured with greater refinement and the angles measured with a better class of instruments.

It was decided that the triangulation should be carried on the bluffs and above the trees of the bottom lands; that a quadrilateral system should in general be obtained and adjusted as such; that the angles should be measured with 10-inch limb theodolites graduated to five minutes and read by two micrometers to single seconds, and that the base lines should approximate two miles in length and be measured with a standard 300-foot steel tape, using standard thermometers to reduce for temperature to 62° Fahr. The required instruments for this were furnished from the office of the Mississippi River Commission; other instruments, such as field theodolites, prismatic compasses, reconnoitering telescopes, &c., were furnished from this office.

FIELD-WORK IN MISSOURI.

The proposed winter's work was to carry the triangulation from the vicinity of Glasgow to the mouth of the river.

On November 15, at Glasgow, three small parties were organized, namely, an observing party on the left bank, consisting of Assistant Engineer D. C. Humphreys, a rodman, and a teamster; an observing party on the right bank, consisting of Assistant Engineer J. C. Quintus, a rodman, a teamster, and a reconnoitering party consisting of myself, a rodman, and boatman. A skiff was furnished the reconnoitering party, and a spring wagon furnished each observing party. A per diem allowance for subsistence had been arranged, and the teamster furnished his own team and its subsistence. The station building and marking and the clearing of lines were in charge of Capt. D. W. Wellman, of the steamer Missouri, who also made the connections of stations with points of tertiary triangulation until the close of river navigation, when the latter duty devolved on the observers. The observers also connected the stations with points of land surveys, and located public buildings in many towns.

The marking stone and pipe were of the same design and dimensions as used by the Mississippi River Commission. The stations were generally of low (5 to 8 feet) tripods, with a target frame outside, built from timber at hand, and when being occupied an observing tent, or a tent fly, was supported by the target frame to screen the instrument from the sun, or strong winds.* The target was always placed vertically above the center of the station, and was the wire target of the Mississippi River Commission. The best target yet devised for the purpose.

In the vicinity of Glasgow ten stations had previously been located and built, but the lines were not all cleared. It was found that three of the lines were impossible on account of intervening ridges between stations, and it was necessary to locate two new stations to help the matter out. Two stations were also located as limits to a base line on the bottom land opposite Glasgow. After the close of river navigation Captain Wellman, at Boonville, placed the station building in charge of an assistant engineer, who had a small party on each bank, each party having a team.

Official word came that "the station building should be pushed as fast as possible"; accordingly I was required to reconnoiter ahead, and was with the observing parties but little during the winter. The reconnoitering to close the work on stations of the Mississippi River Commission was finished on March 24. The map above-

* See photograph No. 1.

mentioned was of great service in reconnoitering, and in finding the location of te tiary triangulation points. County atlases, tax receipts, and deeds were referred in getting the description of the land upon which stations were located.

The consent of parties owning the land was generally obtained, but the cutting timber, or the obstruction of a station to cultivation, generally gave dissatisfactio and many claims for damages were presented. It would be well if the assistant we furnished with a contract form, with instructions to guide in making a contract the beginning, before the owner's estimate for damages becomes excessive.

I would here state that in a wooded country the winter season is the proper ti to reconnoiter, when the twigs are clear of leaves and the snow on the ground is advantage in showing the outlines of the hills.

During the winter the observing parties had worked under great discouragem on account of the imperfectly cleared lines, having to give much time and labor work that should have been done by the station-building parties. The assistant charge of station-building parties had been very dissipated, and was discharged Captain Wellman, at Hermann, being replaced by Assistant Engineer Merserea March 7. The work was carried on energetically to the Coast Survey station, Tav Rock, about 38 miles west from Saint Louis, where a good connection being ma with a Coast Survey line, and through this with the Mississippi River triangulati it was decided to close the winter's work. A Coast Survey line was also connec with at Jefferson City.

During the latter six weeks I was with or near the observing parties, and assis with my small party in the setting of targets, and in seeing that the lines were ma clear. There was yet much to be done in the clearing of lines between Jefferson C and Hermann, and the observing parties were hindered somewhat, yet the number stations occupied in the last six weeks was 35 against 34 previously occupied.

It is proper here to state that the winter being severe, with much snow, at time was difficult to make out the black and white target as projected against trees a snow-covered hills; that the targets were sometimes disturbed by sleet storms; th the instruments worked hard when extremely cold, and that for such reasons the t angles did not always close within the 6″ limit, and it was frequently necessary reoccupy stations.

On the resignation of Mr. Quintus, on May 8, Mr. Bathurst Smith, rodman, w promoted to assistant engineer and observer.

The field was completed on May 13, and the observing parties came to Saint Lo preparatory to leaving for field duty in Montana. There had been 69 stations occ pied, giving 129 triangles and 35 quadrilaterals over an axillary distance of 155 mil

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers U. S. A., Secretary Missouri River Commission.

APPENDIX A 1*b*.

MEASUREMENTS OF THE GLASGOW BASE.

The two measurements of the Glasgow Base are expressed by the following equations:

$$(1)\quad 26\times299'.079+\frac{1\text{ tape}+\text{foot}}{2}-1'.475\pm0'.000-0'.453-0'.920=7923'.237.$$

$$(2)\quad 26\times299'.079+\frac{1\text{ tape}+\text{foot}}{2}-1'.033-0'.667-0'.453-0'.523=7923'.403.$$

Where:

First term is number of entire tapes multiplied by length of tape at 62° Fahr.

Second term is distance between the respective measurement marks on zinc 26 and, in each measurement, the mean of the two successive marks on zinc 26½, as measured by applying 150 feet of tape successively under a strain of 16 pounds, and for the last 150 feet applying one foot of a box-wood scale to the 299-foot graduation to make out the 150 feet. This distance is, for each measurement when reduced to 62° Fahr., = 150′.031 and 150′.025 respectively.

Third term is distance, for each measurement, between the mean of two successive marks on zinc 26½, as above, and △ West Base as measured with a box-wood scale.

Fourth term is distance set back on zinc 23 on second measurement.

Fifth term is total inclination-of-tape correction.

Sixth term is temperature correction to reduce 26 tapes at tape temperature to 62° Fahr., and the second member is the corrected independent result for each measurement.

The mean of the two results is 7,923′.320. The probable error, from the results themselves, is ±0′.056, or one in 140,000.

A truer result can be obtained, it is believed, by combining, as stated in the field-notes at the time of measurement, the first fifteen tapes of the first measurement with the eleven and a half of the second. (See note under table of temperature.)

We then have the following four equations for parts of the base with terms as above described, except that the sixth term is temperature correction for 15 tapes and 11 tapes respectively, and a seventh term is added to reduce the first measurement to the second on zinc 15.

First part of (1):

$$15\times299'.079\pm000'.000\pm0'.000\pm0'.000-0'.260-0'.625+0'.335=4485'.635.$$

First part of (2):

$$15\times299'.079\pm0'.000\pm0'.000\pm0'.000-0'.260-0'.230\pm0'.000=4485'.695.$$

Second part of (1):

$$11\times299'.079+150'.031-1'.475\pm0'.000-0'.193-0'.294-0'.335=3437'.603.$$

Second part of (2):

$$11\times299'.079+150'.025-1'.033-0'.667-0'.193-0'.292\pm0'.000=3437'.709.$$

The result thus obtained is the sum of 4485′.635 and 3437′.709, or 7923′.344.

Glasgow Base (at its own elevation above sea-level)=7923′.344.

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer.

First Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

Temperatures of Glasgow Base.

Number of tape.	First measurement.			Second measurement.		
	November 4, 1885—time.	Thermometers.		November 4, 1885—time.	Thermometers.	
		G.	H.		G.	H.
	A. M.			P. M.		
1	8 24	42.0	42.0	2 22½	56.0	56.0
2	30	42.0	42.0	26	57.5	58.0
3	34	41.5	42.0	29	57.5	56.0
4	39	41.5	42.5	33	57.0	56.0
5	45	44.0	44.0	40	57.0	60.0
6	9 00	43.8	43.5	45	56.0	56.0
7	04	42.8	43.0	49	55.5	55.5
8	08	42.9	43.5	53	57.5	56.25
9	12	43.0	43.5	3 00	57.5	55.0
10	18	43.3	43.0	05	55.5	55.5
11	23	43.0	44.0	08	56.5	55.5
12	26	43.7	44.0	12	56.0	56.5
13	32	43.1	43.0	16	54.0	54.0
14	40	43.4	43.0	20	52.5	52.5
15	45	43.0	43.5	24	51.1	51.5
Sum	....	643.0	646.5	....	837.1	834.25
Mean of 15	....	42.87	43.10	....	55.81	55.62
Correction	....	—0.78	....	....	—0.93	....
Corrected mean	....	42.09	....	....	54.88	....
16	11 55	49.7	50.0	3 27	50.8	51.6
17	58	50.4	50.25	31	50.2	51.0
18	12 03	50.3	51.0	35	50 2	51.5
19	07	49.8	50.0	39	50.2	51.0
20	10	51.0	50.25	43	50.1	51.0
21	14	51.2	52.0	47	50.0	51.0
22	18	51.1	51.0	51	50.0	50.5
23	22	50.0	49.5	56	50.3	51.0
24	28	49.0	49.0	4 10	50.9	52.5
25	31	40.3	49.5	13	50.9	52.0
26	38	50.9	57.0	20	50.5	52.0
Sum	....	552.7	550.5	....	554.1	565.1
Mean of 11	....	50.25	50.86	....	50.37	51.37
Correction	....	—1.02	....	....	—1.02	....
Corrected mean	....	49.23	....	....	49.25	....
Mean of 26	....	45.99	46.88	....	53.51	53.82
Correction	....	—0.89	....	....	—1.11	....
Corrected mean	....	45.10	....	....	52.40	....
26½	12 51	54.6	54.9	4 30	48.9	50.25
Correction	....	—1.13	....	....	—0.99	....
Corrected 26½	....	53.47	....	....	47.91	....

NOTE.—"G" is a compared thermometer belonging to the Mississippi River Commission, and "H is an uncompared one (graduated to 2° intervals) belonging to Mr. D. C. Humphreys.

The first part of the first measurement was made during a cool, cloudy morning, but the second par was made when the sun, at times, had direct effect on the thermometer. The first part of the secon measurement was made when the sun had direct effect, but the thermometer bulb was within a loos coil of wire to shade it from the direct rays of the sun. The wire was of about the same shade of colo as the tape. The second part of the second measurement was made when the sun had no direct effec on the thermometer, being completely overcast.

Correction for inclination of tape on Glasgow Base.

[Sin $i = \frac{h}{l}$; correction = ver sin $i \times l$; i = angle of inclination; h = difference of elevation; l = length of tape.]

Number of stake.	Elevation.	Difference of elevation.	Log h.	Log sin i.	i.	Log ver sin i.	Log correction.	Correction.
					° ′			
△ East Base	100.0	......	....	....	.....	....	....	....
Zinc 0	101.1	1.1	....	....	.....	....	....	....
1	97.9	3.2	0.50515	8.02936	37	5.70282	8.23861	0.0173
2	102.1	4.2	0.62325	8.14746	48	5.98890	8.46469	0.0292
3	99.8	2.3	0.36173	7.88594	26	5.45637	7.93210	0.0086
4	98.3	1.5	0.17609	7.70030	17	5.08732	7.56311	0.0037
5	107.0	8.7	0.93952	8.46373	1 40	6.62639	9.10218	0.1261
6	104.9	2.1	0.32222	7.84643	24	5.38084	7.86263	0.0073
7	99.8	5.1	0.70757	8.23178	59	6.16812	8.64391	0.0441
8	101.1	1.3	0.11394	7.63815	15	4.97860	7.45439	0.0028
9	104.5	3.4	0.53148	8.05569	39	5.80855	8.28434	0.0192
10	104.4	0.1	9.00000	6.52421	01	2.62642	5.10221	0.0000
11	104.1	0.3	9.47712	7.00133	03	3.58067	6.05646	0.0001
12	104.6	0.5	9.69897	7.22318	06	4.18273	6.65852	0.0005
13	104.2	0.4	9.60206	7.12627	05	4.02436	6.50015	0.0003
14	104.1	0.1	9.00000	6.52421	01	2.62642	5.10221	0.0000
15	104.8	0.7	9.84510	7.36931	08	4.43260	6.90839	0.0008
Correction for 15 tapes	......	....	....	....	.....	....	....	0.2600
16	102.0	2.8	0.44716	7.97137	32	5.63072	8.11251	0.0130
17	108.6	6.6	0.81954	8.34375	1 16	6.38803	8.86382	0.0730
18	102.6	6.0	0.77815	8.30236	1 09	6.30411	8.77990	0.0602
19	103.9	1.3	0.11394	7.63815	15	4.97860	7.45439	0.0028
20	102.6	1.3	0.11394	7.63815	15	4.97860	7.45439	0.0028
21	103.5	0.9	9.95424	7.47845	10	4.62642	7.10221	0.0013
22	104.6	1.1	0.04139	7.56560	13	4.85431	7.33010	0.0021
23	102.7	1.9	0.27875	7.80296	22	5.31127	7.78706	0.0061
24	101.6	1.1	0.04139	7.56560	13	4.85431	7.33010	0.0021
25	101.4	0.2	9.30103	6.82524	02	3.22848	5.70427	0.0001
26	105.5	4.1	0.61278	8.13699	47	5.97061	8.44640	0.0280
Zinc 26½ (140′)	104.7	0.8	9.90309	7.72700	18	5.13697	7.81306	0.0020
Top of pipe	103.9	....	....	....	.....	....	....	....
Correction for 11 tapes	......	....	....	....	.....	....	....	0.1935
Correction for 26½ tapes	......	....	....	....	.....	....	....	0.4535

Measurement of the differences at end of each tape—Glasgow Base.

Number of stake.	Second measurement—First measurement.			Remarks.
	Readings on zincs.	Corrections.	Reduced.	
	″	″	″	
1	+0.30	....	+0.30	The second measurement is taken as a standard and the differences recorded as corrections to the first measurement.
2	+0.67	....	+0.67	
3	+1.02	....	+1.02	
4	+1.28	....	+1.28	
5	+1.51	....	+1.51	
6	+1.72	....	+1.72	
7	+2.04	....	+2.04	
8	+2.35	....	+2.35	
9	+2.69	....	+2.69	
10	+2.98	....	+2.98	
11	+3.25	....	+3.25	
12	+3.45	....	+3.45	
13	+3.64	....	+3.64	
14	+3.85	....	+3.85	
15	+4.02	....	+4.02	
16	+3.93	....	+3.93	
17	+3.77	....	+3.77	
18	+3.62	....	+3.62	
19	+3.45	....	+3.45	
20	+3.27	....	+3.27	
21	+3.15	....	+3.15	
22	+3.02	....	+3.02	
23	+3.04	....	+3.04	
24	−4.95	+8.00	+3.05	Set back 8″.00 on zinc No. 23 of the second measurement.
25	−4.95	....	+3.05	
26	−5.17	....	+2.83	
26½	−5.31	....	+2.69	

APPENDIX A 2.

SECONDARY TRIANGULATION OF THE MISSOURI RIVER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., July 12, 1886.

SIR: I have the honor to submit a report on the secondary triangulation of the Missouri River for the year ending June 30, 1886, and to include the results of the least square adjustment of the triangulation in Montana.

The work was begun at Benton, Mont., early in July, and completed to Trover's Point on the 30th of September, a distance, by river, of about 240 miles. There were 94 stations occupied and two base lines measured, one at either end of the work. Observations for the azimuth of the base lines were taken on five nights. Observation for the approximate latitude of one azimuth station was obtained, while that for the other was transferred by triangulation from a point the latitude and longitude of which is published. (See Appendix A 2, Table II.)

After returning from Montana, the steel tape used in base-line measurements was standardized by measuring a known distance of 2 miles on a primary base line. Also, a secondary base line was measured at Glasgow, Mo., and observations for its azimuth made. The work of reduction was then commenced by myself with one assistant. The nine individual measurements on the four base lines were reduced and reports submitted.

The field computation of the Montana triangulation was received and the angles tabulated preparatory to the least square adjustment. There was no run of micrometer applied, since the mean run for one revolution from 31 determinations on one instrument and 40 on the other was not more than one-tenth of a second of arc, and this correction is as likely to be plus as minus in each of the eight changes of the circle for each angle.

The correction for spherical excess was also insignificant, for the total area of the net—177 miles in axial length by 2¼ miles in mean width—is less than 500 square miles, or the spherical excess less than 7″ (at 1″ for every 75 square miles), and this is to be distributed through 90 triangles, or 270 angles. The greatest area of any one triangle is 13¼ square miles, or the greatest spherical excess for any angle of any triangle is less than one-tenth of a second. (In transferring azimuth in the geodetic computation, however, care was taken to eliminate the spherical excess by alternately adding and subtracting the plane angle.)

The system was a series of quadrilaterals. There were, however, seven figures with more than four sides and one quadrilateral in which one diagonal was not obtained. The angle adjustment has been practically rigid with one exception. The Hawley Bend net of seven stations gave eleven angle equations and six side equations. To simplify this adjustment only one side equation was introduced, and that required that the last side computed from the first should be the same by two routes only. In testing this adjustment it was found that the greatest discrepancy in the length of any line, in the figure computed by different routes, was 36 in the seventh place of logarithms, or one in 121,000 parts of the line.

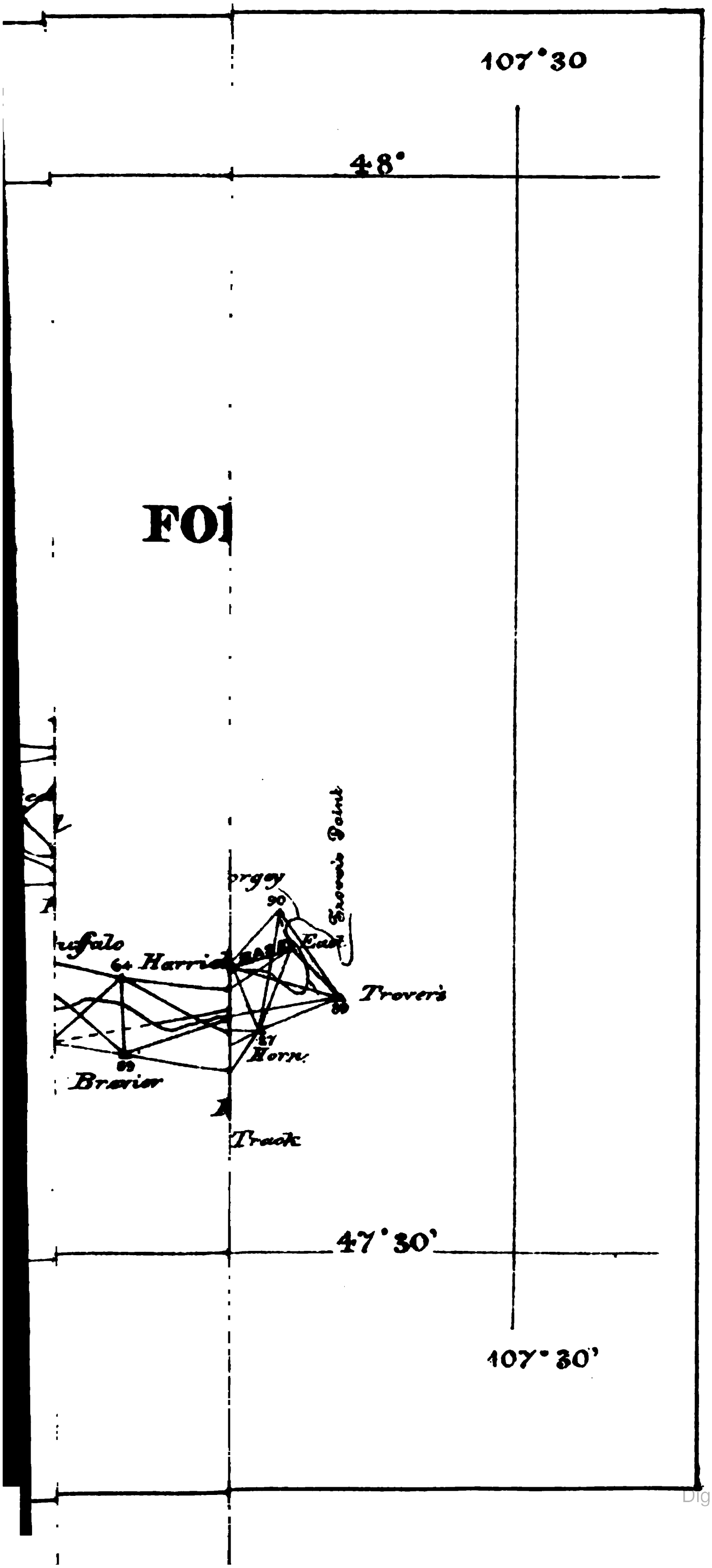
The number of combined angles entering into the adjustments was 388, and the corrections to these lie as follows:

Between 0″ and 1″ 270
Between 1″ and 2″ 102
Between 2″ and 3″.08 16

The computation of the triangulation from Benton Base to Trover's Point Base was through 90 triangles, and the results in Table I depend on the following data:

Bases reduced to sea level.		Observed azimuth of bases.	
	Meters.		° ′ ″
Benton	3008.06	East Base to West Base	73 01 06.73
Trover's Point	2959.84	West Base to East Base	251 29 12.23

and the transferred latitude and longitude of station East Base, Benton, as 47° 59′ 26″ and 110° 40′ 63″, respectively.


107°30
48°
FO
Harri
East
Trover's
Horn
Track
47°30'
107°30'

The bases were reduced to sea-levels, the former for an elevation of 2,900 feet, the latter for an elevation of 2,244 feet. Clarke's value of the logarithm for converting feet to meters, namely, 0.5159890, was used, and the geodetic computation conforms to Clarke's Spheroid.

The discrepancies in length of line and azimuth on the first computation with the adjusted angles were as follows:

	Log. meters.	Azimuth.		
		°	′	″
Trover's Point, base measurement	3.4712689	251	29	10.18
Computed, from Benton	3.4713670	251	29	12.23
Difference	981			2.05

This is a discrepancy of one in 4,400 in the length of line, while that in azimuth is within the range of star determination on different nights.

These discrepancies were distributed through the 39 parts of which the system is made up by allotting one thirty-ninth of the discrepancies to the first part, two thirty-ninths to the second part, &c. The angles of the adjustments have not been changed, and it will be found that the lower line of any quadrilateral, as tabulated, is less by 25 in the seventh place of logarithms than a value computed from the upper line. This is a local discrepancy of about one in 125,000 parts of the length of line, or practically of no import.

The observed value for the latitude of station West Base, Trover's Point, as given in Table III, is less than that computed in Table I by 23″.7, but since the former is only approximate it is thought best to retain the latter, although the reliability of the value upon which it depends is not known, expecting that a constant correction in both latitude and longitude will be applied when accurate determinations of these have been made.

All computations are in ink, in duplicate, with explanatory notes, and, together with the note-books, put in proper form for filing.

In the accompanying sketch the river is only very approximately located, since the topography has not, as yet, been done.

I wish to commend the method used in the astronomical work of making one-half the observations on the star, or sun, upon the reflected image from an artificial horizon, and thus eliminating the level error. The plan of observation was to eliminate, as far as possible, all instrumental errors. Without the necessity for reading the level the observations can be made much more rapidly, and thus the set completed under the most favorable position of the object, and when a large error in time would have the least effect on the result.

It would seem that the bases are now measured with all desirable accuracy, but that attention must be paid to the targets and to the readings of angles, that this accuracy may not be too soon lost in the transfer by triangulation. If greater accuracy is desired than is found in the present work, the bases must be nearer together and the angles read, in general, after 3 p. m., when the atmosphere is steady. (The results at any station would be greatly bettered if the angles were read on different days.)

I have to thank the observers, Assistant Engineers D. C. Humphreys and Bathurst Smith, for the faithfulness with which the adopted plans were carried out in the field, and also Assistant Engineer C. V. Mersereau through all the office computations, and Mr. Smith, while assigned to me, for the faithful aid rendered.

Very respectfully, your obedient servant,

O. B. WHEELER,
United States Assistant Engineer.

First Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

TABLE I.—*Calculated results of secondary triangulation from Benton to Trover's Point.*

Distances and azimuths are in the order of stations, 1st to 2d, 2d to 3d, and 3d to 1st, in each triangle.

Number.	Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
E	East Base	38 54 17.63	18.27	3,009.06	73 01 05.7	47 50 26	110 40 [illegible]
W	West Base........	96 14 52.51	53.89	2,678.85	349 14 17.0	47 49 57.53	110 42 [illegible]
2	Benton	44 50 47.21	47.84	4,240.13	214 05 22.7	47 48 32.32	110 41 [illegible]
		57.35	0.00				
E	East Base	54 28 52.85	52.16	3,009.06	73 01 06.7	....	....
W	West Base........	86 08 53.68	53.73	3,850.60	166 50 29.4	....	....
4	Teton	39 22 14.80	14.11	4,731.36	307 27 44.0	47 51 59.22	110 43 [illegible]
		1.33	0.00				
E	East Base	93 23 10.48	10.43	4,240.13	34 06 47.4	....	....
2	Benton	46 15 40.72	40.81	6,537.16	167 49 41.9	....	....
4	Teton	40 21 10.48	08.76	4,731.36	307 27 44.0	47 51 59.22	110 43 [illegible]
		1.68	0.00				
2	Benton	86 04 45.12	43.56	6,537.16	167 49 41.9	....	....
4	Teton	47 26 16.30	14.47	8,993.40	300 22 38.2	....	....
1	Shonkin..........	46 29 02.84	01.97	6,639.53	73 58 12.8	47 49 31.80	110 36 [illegible]
		4.32	0.00				
4	Teton	33 49 45.83	44.82	8,993.40	300 22 38.2	....	....
1	Shonkin..........	87 07 12.15	13.34	5,837.99	207 34 28.1	....	....
6	Crocon...........	59 03 00.26	01.84	10,472.21	86 39 06.5	47 52 19.33	110 34 40.55
		58.24	0.00				
1	Shonkin..........	39 31 18.86	18.00	5,837.99	207 34 28.1	....	....
6	Crocon	43 08 57.59	56.77	3,745.72	344 27 07.7	....	....
3	Harvey	97 19 47.66	45.23	4,025.48	67 07 58.2	47 50 23.49	110 33 [illegible]
		4.11	0.00				
6	Crocon...........	49 27 42.84	40.83	3,745.72	344 27 07.7	....	....
3	Harvey	91 07 55.61	53.59	4,484.08	255 35 37.0	....	....
5	Brulé............	39 24 27.50	25.58	5,899.21	115 02 37.6	47 50 58.56	110 30 22.[illegible]
		6.04	0.00				
6	Crocon...........	71 39 52.11	50.89	5,899.21	294 59 26.9	....	....
5	Brulé............	45 05 44.09	42.88	6,271.31	160 08 20.4	....	....
8	Tele..............	63 14 27.45	26.23	4,679.44	43 21 30.7	47 54 00.52	110 33 [illegible]
		3.65	0.00				
5	Brule	58 53 00.25	00.00	6,271.31	160 08 20.4	....	....
8	Tele..............	67 45 48.11	47.72	6,691.69	272 21 16.6	....	....
7	Black Bluff	53 21 12.19	12.28	7,235.01	39 04 03.1	47 54 00.50	110 26 44.[illegible]
		0.55	0.00				
8	Tele..............	47 16 08.56	07.82	6,691.69	272 21 16.6	....	....
7	Black Bluff	50 09 09.20	09.29	4,956.85	142 34 24.6	....	....
10	Marias	82 34 44.61	43.39	5,180.97	45 07 20.5	47 56 07.92	110 29 [illegible]
		2.56	0.00				
7	Black Bluff	86 50 28.08	28.21	4,956.85	142 34 24.6	....	....
10	Marias	56 18 46.90	46.86	8,253.46	206 13 50.0	....	....
9	Three Islands	36 50 45.48	44.93	6,877.09	49 27 59.6	47 56 25.30	110 23 33.[illegible]
		1.45	0.00				
10	Marias	51 45 51.96	53.04	8,253.46	206 13 50.0	....	....
9	Three Islands	53 00 33.87	34.21	6,704.54	139 19 18.8	....	....
12	Ridge	75 13 31.34	32.72	6,817.74	34 30 15.1	47 59 09.8[illegible]	110 26 [illegible].11
		57.17	0.00				
9	Three Islands	62 52 14.21	14.36	6,704.54	139 19 18.8	....	....
12	Ridge	68 34 02.52	02.28	7,930.32	250 42 40.1	....	....
14	Recess	48 33 44.37	43.36	8,324.82	22 13 25.9	48 00 34.84	110 20 [illegible].64
		1.10	0.00				
9	Three Islands	33 50 25.04	23.20	8,324.82	202 11 33.2	....	....
14	Recess	58 08 37.13	35.71	4,638.62	324 04 50.1	....	....
11	Mound	88 01 03.84	01.09	7,075.09	56 05 26.6	47 58 33.19	110 17 49.[illegible]
		6.01	0.00				
14	Recess	78 17 38.38	39.41	4,638.62	324 04 50.1	....	....
11	Mound	57 39 41.74	42.31	6,533.47	201 46 09.9	....	....
16	Coal Banks	44 02 37.97	38.28	5,637.41	63 50 15.1	48 01 49.63	110 15 52.47
		58.09	0.00				
11	Mound	38 00 47.37	46.32	6,533.47	201 46 09.9	....	....
16	Coal Banks	49 51 26.30	25.59	4,026.83	331 56 11.2	....	....
13	Shanks...........	92 07 49.71	48.09	4,997.89	50 49 31.1	47 59 54.58	110 14 21.[illegible]
		3.38	0.00				
16	Coal Banks........	80 17 53.05	55.77	4,026.83	331 56 11.2	....	....
13	Shanks.	71 45 58.93	50.44	8,471.83	223 43 18.5	....	....
18	Old...............	27 56 04.15	04.79	8,163.18	71 42 53.5	48 03 12.72	110 09 38.[illegible]
		56.13	0.00				
13	Shanks...........	60 15 33.14	31.79	8,471.83	223 43 18.5	....	....
18	Old...............	53 19 47.74	47.11	8,026.54	350 27 06.6	....	....
15	Iron..............	66 24 41.16	41.10	7,414.68	104 03 08.2	47 58 56.44	110 08 34.14
		2.04	0.00				
18	Old...............	39 39 45.04	45.01	8,026.54	350 27 01.6	....	....
15	Iron..............	69 42 29.71	29.45	5,430.45	240 10 18.7	....	....
20	Sandy.............	70 37 46.81	45.54	7,980.14	130 50 53.3	48 00 23.81	110 04 46.[illegible]
		1.56	0.00				

TABLE I.—*Calculated results of secondary triangulation, &c.*—Continued.

Number.	Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
15	Iron	58 30 58.86	31 60.30	5,430.45	240 10 18.7	....	....
20	Sandy	73 41 36.27	36.67	6,252.37	346 31 31.1	....	....
22	Burned	47 47 23.65	23.03	7,036.72	118 45 00.0	47 57 06.97	110 08 36.63
		58.78	0.00				
15	Iron	32 53 39.78	40.62	7,036.72	298 41 19.0	....	....
22	Burned	74 02 08.12	08.68	8,992.58	44 42 51.4	....	....
17	White cliffs	73 05 08.66	10.70	7,071.21	151 36 00.3	47 55 35.09	110 05 51.95
		56.56	0.00				
22	Burned	53 18 06.90	06.57	8,992.58	44 42 51.4	....	....
17	White cliffs	93 12 33.48	33.27	5,579.00	317 53 44.3	....	....
24	Castle	34 29 20.31	20.16	7,039.88	172 25 18.0	47 53 21.03	110 02 51.89
		0.69	0.00				
22	Burned	34 23 18.71	18.41	7,039.88	352 24 44.8	....	....
24	Castle	51 50 06.03	05.89	3,983.15	120 35 12.0	....	....
19	Wellman	93 47 35.57	35.70	5,547.14	206 45 33.8	47 54 26.63	110 05 37.00
		0.31	0.00				
24	Castle	70 45 53.52	53.28	3,983.15	120 35 12.0	....	....
19	Wellman	58 41 26.19	24.87	4,870.70	359 14 34.4	....	....
21	Kipps	50 32 42.35	41.85	4,407.43	229 47 18.6	47 51 48.93	110 05 33.91
		2.06	0.00				
24	Castle	54 36 57.18	58.62	4,407.43	49 49 18.8	....	....
21	Kipps	76 14 39.92	40.87	4,751.21	306 01 59.5	....	....
26	Citadel	49 08 21.13	20.51	5,660.49	175 12 37.0	47 50 18.40	110 02 29.14
		58.23	0.00				
21	Kipps	44 32 02.19	01.82	4,751.21	306 01 59.5	....	....
26	Citadel	71 37 50.42	49.94	3,712.58	54 26 26.5	....	....
23	La Barge	63 50 06.37	08.24	5,023.89	170 34 30.6	47 49 08.47	110 04 54.33
		58.98	0.00				
26	Citadel	83 42 07.40	07.39	3,712.58	54 26 26.5	....	....
23	La Barge	71 49 53.28	52.72	8,909.92	306 14 31.6	....	....
25	Wall	24 28 01.49	27 59.89	8,517.10	150 46 47.2	47 46 17.77	109 59 09.19
		2.17	0.00				
26	Citadel	28 55 07.84	07.94	8,517.10	330 44 19.1	....	....
25	Wall	69 35 25.54	25.45	4,164.45	220 23 12.6	....	....
28	Pinnacles	81 29 25.46	26.61	8,071.28	121 53 15.3	47 48 00.48	109 56 59.57
		58.84	0.00				
25	Wall	86 23 53.48	55.07	4,164.45	220 23 12.6	....	....
28	Pinnacles	64 06 46.37	47.98	8,452.14	336 15 00.7	....	....
27	Rondeau	29 27 15.25	16.95	7,621.24	126 49 44.7	47 43 49.96	109 54 16.21
		55.10	0.00				
28	Pinnacles	33 56 11.65	12.29	8,452.14	336 15 00.7	....	....
27	Rondeau	77 27 35.30	33.36	5,067.90	233 44 34.9	....	....
30	Pablos	68 36 17.38	14.35	8,861.19	122 23 14.5	47 45 26.96	109 50 59.90
		4.33	0.00				
27	Rondeau	36 49 38.51	39.16	5,067.90	233 44 34.9	....	....
30	Pablos	80 39 18.39	19.74	8,424.16	333 07 40.4	....	....
32	Tip Top	62 31 00.43	01.10	5,636.76	90 37 34.2	47 43 48.06	109 49 45.72
		57.33	0.00				
27	Rondeau	34 36 17.42	18.08	5,636.76	270 34 14.0	....	....
32	Tip Top	108 59 07.27	06.60	5,393.25	341 38 27.6	....	....
29	Arrow	36 24 36.06	35.37	8,979.99	125 14 52.5	47 41 02.81	109 48 24.27
		0.75	0.00				
32	Tip Top	55 51 40.23	41.24	5,393.25	341 38 27.6	....	....
29	Arrow	70 36 06.74	08.45	5,550.51	232 15 36.1	....	....
34	Plateau	53 32 09.12	10.31	6,325.42	105 50 22.2	47 42 52.26	109 44 53.60
		56.09	0.00				
29	Arrow	38 16 29.45	28.50	5,550.51	232 15 36.1	....	....
34	Plateau	89 28 01.20	27 59.56	4,347.77	322 50 12.3	....	....
31	Pines	52 15 34.34	31.94	7,018.69	90 36 13.5	47 41 00.06	109 42 47.76
		4.99	0.00				
34	Plateau	97 17 12.90	12.74	4,347.77	322 50 12.3	....	....
31	Pines	42 19 29.86	29.70	6,655.71	185 11 15.1	....	....
36	Valley	40 23 17.31	17.56	4,518.01	45 34 54.2	47 44 34.68	109 42 18.33
		59.57	0.00				
31	Pines	63 43 05.86	05.96	6,655.71	185 11 15.1	....	....
36	Valley	58 29 25.31	25.97	7,058.07	306 42 10.5	....	....
33	Judith	57 47 28.52	28.07	6,706.37	68 58 03.1	47 42 18.10	109 37 47.64
		59.69	0.00				
36	Valley	55 37 24.74	25.25	7,058.07	306 42 10.5	....	....
33	Judith	76 14 10.99	10.15	7,816.02	202 59 41.3	....	....
38	Council	48 08 24.91	24.60	9,196.08	71 09 54.4	47 46 11.04	109 35 21.00
		0.64	0.00				
33	Judith	52 40 39.42	39.45	7,816.02	202 59 41.3	....	....
38	Council	64 39 34.11	34.26	6,997.00	318 21 55.6	....	....
35	Holmes	62 39 45.89	46.29	7,952.03	75 44 54.4	47 43 21.06	109 31 37.94
		59.42	0.00				

TABLE I.—*Calculated results of secondary triangulation, &c.*—Continued.

Number.	Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
38	Counsell	28 35 10.19	09.50	6,907.00	318 21 55.6		
35	Holmes	54 31 40.50	39.18	3,372.23	192 56 19.7		
40	Iron City	96 53 13.51	11.28	5,730.73	100 49 57.8	47 45 08.07	109 31 [illegible]
		4.29	0.00				
35	Holmes	60 59 42.17	42.20	3,372.22	192 56 19.7		
40	Iron City	87 16 43.01	43.03	5,606.43	285 40 08.5		
42	Bear	31 43 35.16	34.77	6,405.50	73 50 40.5	47 44 18.95	109 28 42.30
		0.34	0.00				
35	Holmes	36 53 15.86	15.61	6,405.50	253 56 01.9		
42	Bear	54 27 24.69	25.00	3,845.93	19 32 15.5		
37	Gallatin	88 39 18.93	18.39	5,213.45	110 52 10.5	47 42 21.59	109 27 44.29
		59.48	0.00				
42	Bear	96 40 57.42	55.99	3,845.93	19 32 15.5		
37	Gallatin	54 09 17.50	17.13	7,616.55	253 40 47.0		
39	Dauphin	30 09 46.54	46.88	6,204.47	103 54 53.4	47 43 39.74	109 21 53.44
		1.46	0.00				
42	Bear	44 11 20.15	17.70	6,204.47	283 51 19.5		
39	Dauphin	61 45 46.13	47.20	4,497.80	165 40 40.6		
44	Rapids	74 02 54.65	55.10	5,685.03	59 42 56.1	47 45 51.84	109 22 46.87
		0.93	0.00				
39	Dauphin	34 39 13.46	13.55	4,497.80	165 40 40.6		
44	Rapids	114 13 00.51	01.30	4,947.18	231 26 59.7		
46	Lone Pine	31 07 43.88	45.15	7,934.65	30 21 32.2	47 47 31.63	109 19 49.96
		57.85	0.00				
39	Dauphin	35 46 19.65	19.87	7,934.65	200 19 54.1		
46	Lone Pine	86 19 34.60	34.40	5,475.26	294 01 57.8		
41	Chimney	57 54 06.21	06.73	9,347.19	56 10 49.9	47 46 19.36	109 15 40.81
		0.46	0.00				
46	Lone Pine	33 25 46.46	46.70	5,475.26	294 01 57.8		
41	Chimney	118 43 23.29	23.17	6,085.64	232 48 18.8		
48	Windsor	23 50 49.72	50.13	9,951.85	81 42 01.5	47 48 18.41	109 11 47.58
		59.47	0.00				
41	Chimney	46 17 56.51	56.49	6,085.64	232 48 18.8		
48	Windsor	91 06 30.01	31.51	6,500.87	321 44 39.8		
43	Birds	42 35 31.01	32.00	8,990.41	90 11 30.9	47 45 33.08	109 08 34.56
		58.43	0.00				
48	Windsor	53 44 35.39	36.25	6,500.87	321 44 39.8		
43	Birds	83 13 57.07	56.69	7,682.88	225 00 59.6		
50	Sturgeon	43 01 26.71	28.06	9,461.31	88 05 41.1	47 48 28.83	109 04 13.39
		59.17	0.00				
43	Birds	37 13 51.69	51.70	7,682.88	225 00 59.6		
50	Sturgeon	69 23 34.25	34.27	4,851.12	335 40 38.7		
45	Spruce	73 22 35.12	34.03	7,504.98	82 19 15.8	47 46 05.71	109 02 37.40
		1.06	0.00				
50	Sturgeon	73 43 46.62	47.95	4,851.12	335 40 38.7		
45	Spruce	67 15 47.69	48.59	7,398.74	222 57 38.4		
52	Snake Point	39 00 22.94	23.46	7,108.48	62 01 01.4	47 49 09.95	108 58 36.05
		57.25	0.00				
45	Spruce	58 42 09.73	11.26	7,398.74	222 57 38.4		
52	Snake Point	54 10 29.68	29.77	6,861.91	348 50 08.1		
47	Cow Island	67 07 17.79	18.97	6,511.16	101 43 36.4	47 45 22.98	108 57 31.36
		57.20	0.00				
52	Snake Point	31 13 37.50	39.43	6,861.91	348 50 08.1		
47	Cow Island	82 10 47.31	48.42	3,881.20	251 01 43.8		
54	Landing	66 33 31.05	32.15	7,409.59	187 37 26.4	47 46 03.80	108 54 33.00
		55.95	0.00				
47	Cow Island	73 32 52.97	52.27	3,881.20	251 01 43.8		
54	Landing	66 14 20.82	20.31	5,765.82	4 49 33.9		
49	Bend	40 12 48.31	47.42	5,501.89	144 36 30.2	47 42 57.78	108 54 58.37
		2.10	0.00				
54	Landing	58 09 04.66	05.21	5,765.82	4 49 33.9		
49	Bend	57 09 02.28	01.41	5,416.97	241 58 18.1		
56	Fortress	64 41 52.69	53.38	5,357.35	126 43 01.3	47 44 30.14	108 51 06.76
		59.63	0.00				
49	Bend	61 50 19.38	19.46	5,416.97	241 58 18.1		
56	Fortress	44 20 48.74	48.17	4,975.33	17 34 19.7		
51	Crystal	73 42 52.47	52.37	3,951.76	123 50 34.0	47 41 46.56	108 53 20.80
		0.59	0.00				
56	Fortress	67 14 24.54	24.60	4,975.33	17 34 19.7		
51	Crystal	70 06 53.80	53.50	6,772.29	267 40 19.9		
58	Grand Island	42 38 40.72	41.90	6,906.26	130 23 01.8	47 41 55.34	108 46 54.36
		59.06	0.00				
51	Crystal	42 19 01.04	02.15	6,772.29	267 40 19.9		
58	Grand Island	55 39 19.61	19.56	4,608.83	32 05 00.3		
53	Quarter	82 01 38.26	38.29	5,646.19	130 01 55.4	47 39 49.02	108 48 53.46
		58.91	0.00				

TABLE I.—*Calculated results of secondary triangulation, &c.*—Continued.

Number.	Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
58	Grand Island	77 41 38.22	33.49	4,603.83	32 05 00.8	....	....
53	Quarter	51 34 27.59	26.73	5,809.83	268 38 00.4	....	....
60	Willow	50 48 58.09	59.78	4,658.55	134 25 24.8	47 40 09.79	108 44 16.69
		58.90	0.00				
53	Quarter	38 25 20.65	19.60	5,809.83	268 38 00.4	....	....
60	Willow	87 36 25.48	26.19	4,464.50	356 04 58.8	....	....
55	Calf Island	53 58 14.60	14.21	7,177.76	122 06 55.4	47 37 45.57	108 44 02.09
		0.73	0.00				
60	Willow	55 36 37.52	37.63	4,464.50	356 04 58.8	....	....
55	Calf Island	71 31 54.62	54.58	4,621.74	247 37 04.1	....	....
62	Buffalo	52 51 27.94	27.79	5,312.29	120 31 03.2	47 38 42.50	108 40 37.38
		0.08	0.00				
55	Calf Island	46 52 06.46	06.83	4,621.74	247 37 04.1	....	....
62	Buffalo	91 56 12.61	13.11	5,119.45	335 44 22.8	....	....
57	Armel	41 12 39.17	40.06	7,011.07	114 32 56.6	47 36 11.37	108 38 56.63
		58.24	0.00				
62	Buffalo	51 16 28.90	28.54	5,119.45	335 44 22.8	....	....
57	Armel	72 47 10.25	10.80	4,821.03	228 32 47.5	....	....
64	Harriet	55 56 21.62	20.66	5,902.79	104 31 16.0	47 37 54.67	108 36 03.55
		0.77	0.00				
57	Armel	52 53 27.41	29.32	4,821.03	228 32 47.5	....	....
64	Harriet	48 28 07.70	07.65	3,921.56	00 06 47.6	....	....
59	Brevier	78 38 21.26	23.03	3,681.12	101 28 24.3	47 35 47.70	108 36 03.93
		56.37	0.00				
64	Harriet	82 00 36.02	36.70	3,921.56	00 06 47.6	....	....
59	Brevier	71 38 44.11	44.73	8,751 31	251 45 32.1	....	....
66	Creek	26 20 37.66	38.57	8,387.53	98 11 04.7	47 37 16.20	108 29 25.88
		57.79	0.00				
59	Brevier	28 14 05.74	05.22	8,751.31	251 45 32.1	....	....
66	Creek	91 02 34.38	33.17	4,746.40	340 47 52.9	....	....
61	Rocky Point	60 43 24.15	21.61	10,031.22	100 05 26.4	47 34 51.06	108 28 11.18
		4.27	0.00				
66	Creek	52 46 48.96	50.20	4,746.40	340 47 52.9	....	....
61	Rocky Point	78 46 31.82	31.39	5,050.95	239 35 19.4	....	....
68	Autumn	48 26 36.81	38.41	6,221.50	108 04 31.8	47 36 13.79	108 24 42.64
		57.59	0.00				
61	Rocky Point	44 47 28.61	28.85	5,050.95	239 35 19.4	....	....
68	Autumn	37 26 05.11	06.14	3,591.53	22 11 47.2	....	....
63	Lopp	97 46 23.07	25.01	3,098.76	104 24 34.8	47 34 26.12	108 25 47.56
		57.69	0.00				
68	Autumn	61 09 38.25	38.03	3,591.53	22 11 47.2	....	....
63	Lopp	87 39 22.87	22.34	6,076.13	289 50 21.6	....	....
65	Carroll	31 10 59.62	59.63	6,930.62	141 04 43.1	47 33 19.26	108 21 14.19
		0.74	0.00				
68	Autumn	33 16 24.02	28.83	6,930.62	321 02 09.2	....	....
65	Carroll	56 58 20.01	19.34	3,802.39	198 03 02.4	....	....
70	Ryan	89 45 18.01	16.83	5,810.72	107 49 00.8	47 35 16.31	108 20 17.80
		2.04	0.00				
65	Carroll	61 43 18.97	18.80	3,802.39	198 03 02.4	....	....
70	Ryan	80 59 39.74	39.40	5,527.89	297 04 04.6	....	....
67	Ryan Island	37 17 01.26	01.80	6,199.62	79 49 56.6	47 33 54.80	108 16 22.82
		59.97	0.00				
70	Ryan	32 44 34.64	35.69	5,527.89	297 04 04.6	....	....
67	Ryan Island	70 30 13.51	14.91	3,071.68	187 37 13.3	....	....
72	Plain	76 45 07.32	09.40	5,353.41	84 22 37.1	47 35 33.38	108 16 02.82
		55.47	0.00				
67	Ryan Island	88 52 42.00	41.11	3,071.63	187 37 13.3	....	....
72	Plain	58 38 36.76	36.13	5,719.05	308 58 51.5	....	....
69	Sage	32 28 42.42	42.76	4,884.69	96 32 45.8	47 33 36.83	108 12 30.17
		1.18	0.00				
72	Plain	36 02 47.44	46.97	5,719.05	308 58 51.5	....	....
69	Sage	94 39 32.55	33.01	4,439.31	223 41 01.5	....	....
74	Kannuck	49 17 39.82	40.02	7,519.28	93 00 29.9	47 35 20.75	108 10 03.42
		59.81	0.00				
69	Sage	46 15 19.42	19.08	4,439.31	223 41 01.5	....	....
74	Kannuck	85 40 40.35	38.79	4,311.00	318 02 11.1	....	....
71	Line	48 04 02.43	02.13	5,950.41	89 59 50.7	47 33 36.94	108 07 45.53
		2.20	0.00				
74	Kannuck	36 55 10.15	10.38	4,311.00	318 02 11.1	....	....
71	Line	88 48 26.49	27.11	3,186.57	226 47 20.0	....	....
73	Across	54 21 25.66	22.51	5,303.50	101 10 04.6	47 34 47.57	108 05 54.40
		2.30	0.00				
74	Kannuck	42 42 10.49	12.04	5,303.50	281 07 00.7	....	....
73	Across	79 36 31.20	30.50	4,255.86	180 46 35.1	....	....
76	Hawley	57 41 14.21	17.46	6,172.28	58 27 54.5	47 37 05.36	108 05 51.63
		55.90	0.00				

TABLE I.—*Calculated results of secondary triangulation, &c.*—Continued.

Number.	Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
73	Across	76 16 24.97	26.19	4,255.86	180 46 35.1	....	....
76	Hawley	61 55 16.24	16.79	6,202.13	298 51 20.2	....	....
78	Frost............	41 48 17.38	17.02	5,633.63	77 06 15.1	47 35 28.30	108 01 31.01
		58.59	0.00				
73	Across	31 30 30.80	32.77	5,633.63	257 03 01.1	....	....
78	Frost............	92 14 36.06	39.80	3,516.80	344 51 38.3	....	....
75	Slide	56 24 58.50	25 00.43	6,756.48	106 27 10.3	47 33 38.44	108 00 47.71
		55.96	0.00				
78	Frost............	63 38 18.45	19.05	3,516.80	344 51 38.3	....	....
75	Slide	82 20 43.04	43.41	5,626.25	247 12 54.1	....	....
80	Lake............	34 02 56.80	57.54	6,225.07	101 18 54.9	47 34 48.91	107 56 38.40
		58.18	0.00				
75	Slide	35 58 48.63	46.85	5,626.25	247 12 54 1	....	....
80	Lake............	43 13 15.30	15.41	3,365.06	24 03 41.9	....	....
77	Pike	100 47 54.24	54.74	3,922.30	103 13 58.8	47 33 00.41	107 57 45.06
		58.26	0.00				
80	Lake	81 46 56.26	56.04	3,365.06	24 03 41.9	....	....
77	Pike	46 55 22.86	22.21	4,267.83	260 57 15.7	....	....
82	Cut-off	51 17 41.22	41.75	3,149.70	122 17 10.9	47 33 54.46	107 54 32.06
		0.34	0.00				
77	Pike	48 50 20.67	20.48	4,267.83	250 57 15.7	....	....
82	Cut-off	74 56 10.60	11.32	3,865.48	356 08 26.8	....	....
79	Above	56 13 27.85	28.25	4,257.96	119 50 07.9	47 31 40.59	107 54 13.37
		59.21	0.00				
82	Cut-off	56 27 37.95	38.43	3,865.48	356 03 26.8	....	....
79	Above	81 03 27.65	28.22	4,770.60	257 07 04.4	....	....
84	Hornets	42 28 52.94	53.35	5,664.07	119 38 41.8	47 32 22.97	107 50 37.00
		58.54	0.00				
79	Above	41 46 13.81	14.43	4,770.60	257 07 04.4	....	....
84	Hornets	84 31 38.51	38.86	3,913.17	352 38 00.5	....	....
81	Below	53 42 05.60	06.71	5,892.38	118 56 20.6	47 30 17.34	107 50 12.65
		57.51	0.00				
84	Hornets	29 39 34.76	35.22	3,943.17	352 38 00.5	....	....
81	Below	86 38 30.19	30.88	2,176.61	250 16 58.2	....	....
83	Nest	63 41 53.32	53.90	4,390.98	143 00 07.5	47 30 30.44	107 48 31.05
		58.27	0.00				
84	Hornets	83 03 24.19	25.73	4,390.98	322 58 34.3	....	....
83	Nest	54 10 30.58	32.00	6,419.19	197 10 30.5	....	....
86	Wilson	42 46 01.52	02.27	5,243.22	50 57 48.7	47 33 49.01	107 46 52.05
		56.29	0.00				
83	Nest	36 12 09.40	08.13	6,419.19	197 10 30.5	....	....
86	Wilson	84 51 41.19	40.74	4,426.13	292 30 05.6	....	....
85	Track	58 56 12.58	11.13	7,463.72	53 26 19.0	47 32 54.50	107 43 44.16
		3.17	0.00				
86	Wilson	60 57 22.07	23.56	4,426.13	292 20 05.6	....	....
85	Track	64 23 52.91	53.79	5,815.25	176 46 23.9	....	....
88	Elk	45 38 42.62	42.65	5,582.41	42 24 55.0	47 36 02.50	107 43 52.03
		57.60	0.00				
85	Track	38 29 53.95	54.02	5,815.25	176 46 23.9	....	....
88	Elk	79 11 51.74	51.83	4,088.36	277 34 20.5	....	....
87	Horn	62 18 13.62	14.15	6,451.36	35 18 29.6	47 35 45.01	107 40 45.84
		59.31	0.00				
88	Elk	53 09 51.17	53.88	4,088.36	277 34 20.5	....	....
87	Horn	95 09 08.58	00.53	6,230.20	192 45 53.3	....	....
90	Forgey	31 40 57.26	56.59	7,752.75	44 27 38.6	47 39 01.75	107 39 30.57
		57.01	0.00				
87	Horn	54 09 57.05	56.46	6,230.20	192 45 53.3	....	....
90	Forgey	47 46 57.60	58.63	5,162.75	324 50 43.3	....	....
89	Trovers	78 03 04.71	04.91	4,716.30	66 58 23.2	47 36 44.79	107 37 18.07
		59.36	0.00				
88	Elk	49 57 52.81	55.31	4,088.36	277 34 20.5	....	....
87	Horn	66 39 45.11	46.73	3,501.68	164 16 30.5	....	....
W.	West Base	63 23 16.13	17.96	4,199.20	47 38 14.9	47 37 34.14	107 41 31.39
		54.05	0.00				
87	Horn	30 02 35.41	34.84	3,501.68	164 16 30.5	....	....
W.	West Base	93 46 45.27	46.63	3,950.84	251 29 10.2	....	....
E.	East Base	48 10 37.82	38.53	4,693.37	23 30 11.0	47 38 04.55	107 39 18.85
		58.50	0.00				

TABLE I.—*Calculated results of secondary triangulation, &c.*—Continued.

Additional stations located.

Number.	Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
	At Benton.	° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
	East Base	89 54	10	3,008.06	73 01 05.7	....	....
	West Base	11 04	25	3,064.11	264 03 48	....	....
	Hub	79 01	25	588.52	163 07 02	47 50 07.77	110 39 54.78
			00				
	Hub	43 14	20	3,064.11	81 05 37	....	....
	West Base	85 10	30	2,678.85	340 14 17	....	....
2	Benton	51 35	10	3,896.73	220 49 45	....	....
			00				
	Hub	43 51	05	3,896.73	40 51 17	....	....
2	Benton	37 48	15	2,730.63	258 38 00	....	....
	Flag staff, Fort Benton	98 17	40	2 413.80	176 57 16	47 48 50	110 39 48
			00				
	At Mussel Shell.						
79	Above	82 49	24.16	5,892.38	208 53 18.8	....	....
81	Below	36 06	49.73	6,680.24	82 49 30.9	....	....
	Raid	61 03	46.11	3,968.36	201 41 51.2	47 20 50.21	107 55 29.51
			0.00				
79	Above	76 37	32.01	5,892.38	208 53 18.8	....	....
81	Below	56 57	49.29	7,914.62	61 58 31.3	....	....
	Cow Boy	46 24	38.70	6,819.09	105 29 46.6	47 28 16.80	107 55 46.48
			0.00				
79	Above	29 06	03.90	5,892.38	208 53 18.8	....	....
81	Below	66 08	49.75	2,877.83	52 47 30.9	....	....
	Williams	84 45	06.35	5,411.78	148 01 03.8	47 29 20.98	107 52 02.33
			0.00				
79	Above	60 39	13.63	5,802.38	208 53 18.8	....	....
81	Below	85 40	14 82	9,263.03	33 16 05.8	....	....
	Mussel Shell	33 40	31.55	10,506.39	179 32 35.4	47 20 06.49	107 54 15.33
			0.00				

TABLE II.

[Instrument, Troughton & Simms's 10-inch theodolite, No. 1.]

Observer.	Star, date, &c.	Result for star.	Resulting azimuth.
Azimuth at east base, Fort Benton. Azimuth of line east base—west base.			
		° ′ ″	° ′ ″
D. C. Humphreys	Polaris near eastern elong., July 19, 1885	73 01 04.26	....
Do	Polaris near eastern elong., July 20, 1885	73 01 04.17	....
Do	Polaris near eastern elong., July 23, 1885	73 01 08.76	73 01 05.73
Azimuth at west base, Trover's Point base line. Azimuth of line west base—east base.			
Bathurst Smith	Polaris near eastern elong., Sept. 26, 1885	251 29 10.71	....
Do	δ Ursa Minor near western elong., Sept. 26, 1885	251 29 12.11	....
D. C. Humphreys	Polaris near eastern elong., Sept. 27 1885	251 29 07.71	251 29 10.18

TABLE III.

[Instrument, Troughton & Simms's 10-inch theodolite No. 1.]

Observer.	Object, date, &c.	Result for object.	Resulting latitude.
Latitude of West Base, Trover's Point base line.			
		° ′ ″	° ′ ″
Bathurst Smith	Sun near meridian September 26, 1885	47 38 01.6	....
D. C. Humphreys	Polaris near meridian September 27, 1885	47 37 54.0	47 37 57.8

APPENDIX A 3.

SECONDARY TRIANGULATION OF MISSOURI RIVER BELOW FORT BENTON.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., March 1, 18

SIR: I have the honor to submit the following digest of records on file in this relative to secondary triangulation along the Missouri River, below Fort Be during the year 1885.

Reports of chiefs of party are appended with full details and reductions of measurements; also tabulated results of leveling.

Very respectfully, your obedient servant,

THEO. A. BINGHAM,
First Lieutenant of Engineers,
Secretary Missouri River Commissi

Maj. C. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

DIGEST OF RECORDS.

The intention is to cover the river valley from bluff to bluff with, as far as possi a quadrilateral system, which has the following advantages over a triangular or h agonal system:

First. It can be employed to better advantage in a mountainous country than hexagonal.

Second. Although at the expense of area covered, it is the strongest of the three regards number of geometrical conditions, and if these are satisfied it gives greatest relative accuracy.

The distance covered during 1885 was 240 miles along the river, beginning at F Benton, July 5, and ending at Trover's Point, Mont., October 1.

Ninety-eight triangulation stations were occupied, determining 200 triangles and quadrilaterals. These stations are all marked permanently. For detailed descripti see Annual Report Mississippi River Commission for 1883, page 164, and Annual R port Missouri River Commission for 1884-'85, Appendix A 2. Fig. 1, Plate 1, he with, shows the pipe cap.

More than 50 per cent. of the triangles close within the limit of primary work (3'

The system depends on two bases, determined one at Fort Benton and the other Trover's Point.

A single line of levels was run over the distance covered by the work. It w checked in part whenever delays permitted. Seventy-two miles were thus check out of 241, 17 being continuous.

An elevation was assumed at Fort Benton of 2,700 feet above Saint Louis directri The fall of the water-surface from Fort Benton to Trover's Point was found to 462'.5 or 1'.99 per mile. The fall in the first 140 miles (foot of Cow Island) is 2'.5 p mile. There were two leveling parties, both working down-stream; the up-strea party ending for the day on the bench-mark where the other began. In this way total of 6 miles a day could be covered.

The total cost of the season's work was $26,400, or $110 per mile; not excessiv considering the remoteness of the work.

ORGANIZATION.

The organization of parties, during 1885, was given in Annual Report for 1884-'8 (Appendix A).

During the season defects were developed which can, it is thought, be entirely ob viated in future by making the parties engaged on different work independent of eac other. Suggestions, given at my request, will be found in Appendices A 3a and A 3b

BASES.

The Fort Benton base is 1.86 miles long and was measured three times. The first, being only a trial measurement is not included in the adopted result. The second and third measurements differed by 0'.055. The mean of these was adopted, giving a length of 9870'.415, with a probable error of $\pm$ 0'.0185, or $\frac{1}{533000}$. Azimuth was determined by three nights, observations on Polaris head elongation. This base was also

connected with United States land surveys and with other known data; and by tertiary triangulation with the flag-staff at Fort Benton, for which the Report on Northern Boundary Survey, 1878, gives: Latitude 47° 48′ 50″ north; longitude 110° 39′ 48″ west from Greenwich.

Full details of measurement are given in Appendices A 3c and A 3d.

The Trover's Point base is 1.83 miles long and was measured three times. The first measurement was a trial one and was not included in the final result. The second and third differed by 0′.023. The mean of these two was adopted, giving a length of 9711′.904 with a probable error of ±0′.0078, or $\frac{1}{1250000}$.

Full details are given in Appendices A 3 c and A 3e.

Azimuth was determined by three nights' observations on stars near elongation. The approximate latitude was also determined.

To measure bases a steel tape was used, obtained from the Mississippi River Commission. The tape was approximately 299′ long. It was marked standard at 62° Fahr., but was known not to be standard at that temperature when under tension to eliminate sags. It was thought to be standard at approximately 36° Fahr. when under tension of 12 pounds. Modulus of elasticity, E, was 27,400,000 pounds. Coefficient of expansion 0′.00000699 for 1° Fahr., as determined by J. B. Johnson for the Mississippi River Commission. In order to determine the lacking information as to the standard temperature under a known tension, the eastern part of the Olney base line (Lake Survey Primary, 1879) was taken as a standard of comparison; its length is known within a limit of $\frac{1}{1013000}$ (Professional Papers No. 24, page 304).

The length of the standard taken is (page 303)	10821′.9662
Length, by tape, under tension of 16 pounds, reduced to 62° Fahr., and for inclination	10819 .0890
Difference	2′.8772

The measurement took 36.184 lengths of the tape; hence ($\frac{2'.8772}{16.034}$ = 0′.1795) the tape was 299′.0795 long at 62° Fahr. under tension of 16 pounds. Expansion for 1° Fahr. for 299′ being 0′.00209, 24° Fahr. results as the temperature at which the tape is 299′ long under pull of 16 pounds. Since 1 pound tension gives an elongation of 0′.00538 and 1° Fahr. an expansion of 0′.00209 for 299′, it follows that the effects of tension and expansion are as 1 to 2.57. Therefore since 24° is standard temperature for 16 pounds pull, 62° will be standard for 1.22, or just about enough to haul taut on a cable. Also 34°.5 will be standard temperature for the 12 pounds tension used by Johnson in his determinations. Such are the checks on the first result. (Details in Appendices A 3c and A 3f.)

Different, 50-feet lengths on the tape were also compared, and the graduation was found to be very satisfactory. (Details of comparison will be found in Appendix A 3c.)

The use of a steel tape, for secondary base measurements, is not new, but has not heretofore proved satisfactory owing mostly to the uncertainty of the temperature correction. Mr. O. B. Wheeler, however, believed that this method could be made satisfactory if care were taken to keep the temperature, during a measurement, nearly constant. To do this he proposed to work only at night, or when the sun was obscured. The first measurement at Fort Benton was made in sunlight. The comparative results can be seen in Appendix A 3c. He also introduced the use of the pieces of zinc on which the measurements were marked off with an engraver's pencil and a square. These zincs are filed as part of the record—an ingenious device. They are long enough to give room for expansion of the tape, but sometimes a set backward or ahead is necessary. Friction is reduced to a minimum by the suspension of the tape in swinging hooks. The tape does not have to be kept level, and so is available for almost any surface and does not require special preparation of the ground other than clearing. A checked line of levels is run to determine correction for inclination.

The results show the great accuracy attainable with the steel tape by Mr. Wheeler's method. (See Appendices A 3c, A 3d, A 3e, and A 3f.)

BASE-MEASURING APPARATUS.

(1) *The rear adjuster* (see photographs 303 and 304 and figs. 1 and 2, Plate II).—This consists of a wooden screw, A, fixed in a block, B. The screw by its revolution causes a nut, C, to move along it. The head plate B has dogs fastened in its bottom by which it is secured to the straining stake on which it rests. When in use, the tape is attached to the movable nut C; and a wire guy, about 3 feet long, leads from the rear end of the screw-block B to an iron pin in the ground in rear.

(2) *The front adjuster* (see photographs 300, 301, and 302; figs. 3 and 4, Plate II).—This consists of a wooden screw, A, fixed in a block, B. The screw by its revolution

causes a nut, C, to slide in a groove on the head D and push against an iron fulcrum piece, E. The head D has dogs on its under side by which it is fastened to three table stakes. In a notch of the fulcrum piece swings a knife-edge fastened in the corner of the lever block F, at an angle of 45° with the sides of this corner. The knife edge extends beyond the sides of the lever block, and these extensions are the headings. The lever block is of wood, 8¾ inches square, 1 inch thick on top, and 2 inches at bottom, lightened by the removal of the corner diagonally opposite the knife-edge. The sides of the block beginning at the knife-edge give equal lever arms at right angles. A spirit-level, G, is attached to the top of the lever block parallel to the horizontal lever arm and used to make it horizontal when the tape is in position. The tape hook is just in rear of the level. A can of shot, H, is suspended by a hook from the front end of the horizontal lever arm. It, together with the hook end, is placed on a scale and shot poured in until the weight of the whole apparatus turning about the knife-edge is exactly 16 pounds. Two thermometers were used attached to long, stiff wire pins with hooks bent in them. These pins were pushed into the ground so as to bring the bulbs at the level of the tape and a few inches from it. (Photographs Nos. 303–4.) One of the thermometers belongs to the Mississippi River Commission and has been compared with the Lake Survey thermometer, Casella 2142. It has no number of its own but is marked "Tape."

The comparison was made horizontally in water, and the corrections are subtractive and as follows:

Thermometer reading.	Thermometer correction.
°	°
32.4	−0.4
42.3	−0.8
52.5	−1.1
63.2	−1.2
72.0	−1.1
82.6	−0.8
91.0	−0.8

The other, an uncompared thermometer, belonged to Mr. D. C. Humphreys.

(3) *Stakes, &c.* (see photographs 300, 301, 302, 303, and 304).—The line is first cleared; 400 stakes (for a 300-foot tape) 3 feet long and 2 inches by 2 inches are distributed over it. Marking stakes are set in line by transit at every tape length, spaced by the tape under a tension by spring balance of 16 pounds, and driven until their tops are about 10 inches above ground; zinc strips, 1½ inches wide, are then tacked to the tops of the marking stakes parallel to the base line. Three table stakes are then planted 3 feet in advance, and one straining stake 3 feet in rear of each pair of marking stakes. They are adjusted by a test frame so that the tops of table stakes shall be 11¾ inches below and of straining stakes 2 inches below the line of the tops of marking stakes. This will bring the tape when in position barely in contact with the zinc strips. Supporting stakes are then planted on the line, 30 feet apart, with their tops 3 inches above tops of marking stakes. Nails are then driven in the supporting stakes 1 inch below their tops; their heads are inclined slightly below the horizontal and must be in line vertically and horizontally. Against the heads of these nails hang double-ended hooks, of No. 12 wire, 2 inches long, bent in planes at right angles (ʃ). The tape rests in the lower hook and is thus on a line with the tops of the marking stakes.

TACTICS OF BASE MEASUREMENTS.

For a 300-foot tape a party of sixteen is required, distributed as follows: Observer and assistant at rear end; observer, assistant, and attendant at front end; nine helpers, one at each supporting stake; two of these helpers must be able to read thermometers, closely and reliably; one recorder; one chief of party, as superintendent.

The rear observer, as soon as he sees the weight applied, adjusts his end approximately and calls out, "Ready"; the front observer replies, "Ready"; the rear observer calls out, "Mark"; the front observer replies, "Marked."

The thermometer readings are then called out and recorded; time and weather are noted, and all stand ready to march except the front observer; he makes and numbers a line on the zinc, with an engraver's pencil and rule, at right angles to the base, from a point already made by the pencil. This done, he takes the front end of the tape and gives the word, "March." All move rapidly forward, carrying the tape. Each helper carries the tape in its hook ready to suspend from the nail head, in the proper supporting stake. The superintendent watches against twist. Second and third measurements are so numbered on the zincs. Differences are read to the nearest hundredth of an inch before the zincs are taken up.

In daylight a tape length can be measured every two minutes. Candle-light requires 30 per cent. more time. On two occasions during 1885, 32 tapes, or 1.85 miles, were measured in one hour and nine minutes.

AZIMUTHS.

Observations were made by the method given in Professional Papers, No. 24, pages 9–30. Alternate pointings to same stars were to the reflection in an artificial horizon to eliminate level correction. Reductions were made by method given on page 640 of same authority.

TRIANGULATIONS.

The instruments used were Troughton & Simms's non-repeating 10″ theodolites, Nos. 1 and 2. They were obtained from the Mississippi River Commission; they are graduated to five minutes and read by two micrometers to one second. They are peculiar in allowing the circle to be clamped to the axis and to revolve on it when unclamped. (Photograph No. 254.) The micrometers are adjustable by the graduation on the limb. Inequality of pivots is eliminated by method of observation. The value of one division of the striding level was, for No. 1, 2″.00 (see Appendix A 3*g*), for No. 2, 1″.24 (see Appendix A 3*g*). The instruments were mounted on large portable tripods, designed by Mr. D. C. Humphreys, which had also a centering trivet plate. (Photograph Nos. 254 and 256.)

The method followed in reading angles was that given in Professional Papers, Corps of Engineers, U. S. A., No. 24, page 31. The horizon was not closed. Limit of closure of triangles, 6″. Eight combined results are taken as giving a weight unity.

The general method followed in reduction is that given in Col. A. F. Clarke's (R. E.) "Geodesy," page 263, for a simple quadrilateral. In two cases of getting off bases the method as given in Professional Papers, No. 24, page 306, will be used.

The targets used were the wire ones described in Report Mississippi River Commission for 1882, page 45. (See photograph No. 256.) They had a perforated board at bottom, which fitted on the △ projection of the bench-mark cap. When an instrument occupied the station a smaller similar target was lined in at the rear. (Photograph No. 255.)

These targets give no phase and are equally illuminated whether the sun be in front or rear.

PERMANENT LEVEL BENCH-MARKS.

Seventy-six lines across the river valley were established, containing 152 bench-marks. These were connected by lines of levels and tertiary triangulation with the secondary triangulation stations. The lines are, for the present, numbered consecutively from Fort Benton down, the bench-marks being designated from the right bank by a numeral placed under the number of the line, thus, $\frac{5}{1}$ is the notation for the first or right-bank bench-mark on the fifth line.

The permanent marks used are the same as for triangulation stations, except that the pipe is 4′ long. (Described in Annual Report Missouri River Commission for 1884–'85, Appendix A 2.)

LEVELING.

Buff and Berger's 18″ Y-levels were used, with New York rods. The targets had a clamp and tangent motion, designed in the office mainly by Mr. D. W. Wellman. Wooden pegs were used, with round-headed tacks or lath nails, as the support of the rod. Levels for plumbing were attached to the rods.

The instruments were kept under tents except when being transported. Adjustments were made regularly every day, and oftener if necessity were suspected.

Fore and back sights were equalized by pacing or stadia measurements, all the instruments having fixed stadia wires and the rods an extra graduation to correspond. Sights were limited to 300 feet, except in crossing a river or when otherwise impossible. Bubble was kept in the middle.

Three readings of rod were taken at each sight and the mean adopted. These three were required to agree within 0′.001. When one level was checking another repetition was required:

(1) For discrepancies, on single sights, of 0′.006 or more;

(2) For discrepancies, on single sights, of more than 0′.001 per 100′ when pegs were more than 300′ apart.

In crossing the river the parties followed General Comstock's "Instructions for Survey of the Mississippi River," dated Detroit, October 3, 1878. (Details in Appendix A 3*a*.)

Rodmen kept notes of readings on their rods, which readings were called out as a check when the leveler and rodmen alternately passed each other.

Tables given in Appendices A 3*h* and A 3*i* show the difference of elevations of bench-marks and of water-surface, the latter corrected approximately by gauge readings taken during the season at Fort Benton.

Allotment: Surveys between Fort Benton, Montana, and Sioux City, Iowa.

[Itemized expenditures for working season—April 13, 1885, to October 31, 1885.]

On what account.	April.	May.	June.	July.	August.	September.	October.	Paid since in November.	Total.
Repairs to steamer Missouri	$1,241 22	$135 37	$18 00	....	....	....	....	....	$1,[illegible]
Lumber, nails, &c	861 47	1,140 76	108 91	....	....	$133 97	....	....	1,[illegible]
Machinery	24 50	....	....	....	....	....	....	....	[illegible]
Pump	86 65	....	....	....	....	....	....	....	[illegible]
Heater	74 50	....	....	....	....	....	....	....	[illegible]
Transportation	2 00	....	....	....	....	....	....	....	[illegible]
Traveling expenses	....	....	....	....	....	120 60	$165 60	$65 30	[illegible]
Transportation	....	....	....	....	$125 70	....	105 10	8 5-	[illegible]
Pay-roll	....	1,163 66	1,238 33	$2,729 01	2,484 83	3,435 33	3,256 00	314 67	14,[illegible]
Medicine	9 00	21 25	....	....	....	....	....	....	[illegible]
Subsistence	83 00	2,465 65	146 80	193 85	340 48	400 69	261 23	....	3,[illegible]
Fuel	....	242 89	477 89	509 00	242 00	261 00	151 50	....	1,[illegible]
Bench-marks	....	....	312 50	....	....	....	....	....	312 [illegible]
Wire rings, &c	....	....	221 05	....	....	19 65	....	....	[illegible]
Cotton cloth	....	94 24	4 00	....	....	....	....	....	[illegible]
Stationery	....	....	....	....	8 65	15 00	....	1 70	25 [illegible]
Repairs of instruments	....	....	7 50	....	....	....	....	....	7 [illegible]
Total	1,882 34	5,263 82	2,534 98	3,431 86	3,201 16	4,386 24	3,939 43	360 17	25,[illegible]

APPENDIX A 3*a*.

REPORT OF MR. D. W. WELLMAN, ASSISTANT ENGINEER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., December 1, 1885.

SIR: I have the honor to submit, herewith report of operations in the field on the portion under my charge, of the survey of the Missouri River subsequent to the 30th day of June, 1885.

In my report for the year ending June 30, 1885, submitted July 6 last, a brief history was given of the survey of the Missouri River from its commencement to date, with a statement of the work accomplished and description of some of the methods used; also, a report of the progress, up to that date, of the party then organized for the continuation of the survey, commencing at Fort Benton, Montana. The party had then reached the Dauphine Rapid, 95 miles below Fort Benton, at which place it arrived July 4.

The construction of a quarter-boat 15 by 50 feet for the use of the triangulation party, the material for which was brought from Saint Louis on the steamer, was immediately commenced. This work was done principally by the party under my charge, the triangulation party being at once engaged in the preparation and measurement of a base line. The quarter-boat was finished and occupied by the triangulation party on the 18th of the month. On Monday, the 20th, the steamer left Fort Benton and the regular work was begun.

Previous to this, two bench-mark lines had been established and a start made with the levels. The work in hand was erecting △ (triangulation stations) after their location by the assistant in charge of triangulation work, establishing permanent bench-marks and connecting them with the △, and carrying a line of levels on to one or more of the "benches" in each bench-mark line. On account of the small amount of money available for field operations the Commission had directed that no topographical work be attempted.

Immediately after commencing work the organization was found to be somewhat faulty, one branch of the work interfering more or less with the progress of another. By making some changes and adapting the movement of parties to circumstances however, fair but not altogether satisfactory progress was made.

Up to July 31 the work had been carried over 52 miles of river (distance estimated). During the month of August 113 miles was made, and in September, up to the 17th of the month, 73 miles.

On September 17 the work of locating △ was suspended, Assistant Wheeler going back to hasten forward the work of the observers. My party, therefore, being un-

ıle to make further progress, was employed in preparing a base-line for measurement ınd a place for hauling out the observers' quarter-boat. This done, the levelers were et to work checking levels previously run, the parties working up-stream, the steamer ıt the same time moving up to keep pace with them.

Thirty miles of levels were thus checked when, the observers having passed down wo days previous, the steamer returned to the base-line. The observers were delayed ıere two days, a smoky atmosphere and cloudy nights preventing for that length of ime some necessary final observations. By the evening of September 30, however, he observations were completed, the quarter-boat having been hauled out in the ıean time and made safe for the winter; and on the morning of October 1, the steamer, rith all parties on board, started for Bismarck, which place, after considerable delay rom low water and windy weather, during which it was impossible to run, was eached on the 15th of the month. The party was here discharged, and arrangements ıade for hauling out the steamer and placing her in safe winter quarters as soon as he ways then in process of erection at that place were completed. A watchman was eft on the steamer and one on the quarter-boat.

'he number of △ built during the season (July 20 to October 1)	96
łumber of permanent bench marks established	152
'stimated number of miles of river covered	238
łumber of miles of levels run, including running to water-surface from "benches" (of which distance 72 miles were checked)	241

The total fall of river from Fort Benton to end of season's work, as shown by the evels, is 426 feet.

From a reference to the readings on a Fort Benton gauge, which was observed up o September 5, the river appears to have fallen, between the time of the commenceıent and ending of the field work, about 2 feet, which would leave a clear fall in the rater surface of the river of 424 feet, an average of nearly 1.8 feet per mile. From 'ort Benton to foot of Cow Island (140 miles) average fall per mile is nearly 2¼ feet.

The organization of parties was at first as follows: Two parties building trianguation stations, each consisting of 1 foreman and 3 laborers; for connecting permaıent bench-marks with triangulation stations, 1 assistant engineer, 2 rodmen, 1 laorer; levels, 2 levelers, 2 rodmen, 2 shademen, 1 axman, 1 boatman.

The permanent bench-marks were the same as those used on the work inaugurated n the fall of 1884 at Glasgow, Mo., namely, a stone 18 inches square and 4 inches hick, marked U. S. / O / B. M., with a copper bolt ½ inch in thickness leaded into the center of one side, and projecting ½ inch above the surface. This stone was placed 3 feet in he ground, and on it, and centered over the copper bolt, was placed a piece of 4-inch gas-pipe 4 feet long, with a cast-iron cap on the top secured by a bolt and nut through he cap and pipe. The cap is marked in raised letters "Mo. River Commission B. M.," ınd has a rounded projection in the center ½ inch high. The real "permanent benchıark" is the copper bolt, which is reached by taking off the cap and letting the rod lown through the pipe on to the top of bolt.

The marks were set on lines crossing the valley, estimated to be an average disance of 3 miles apart, and the valley being narrow in this portion, only 2 benches rere placed in a line, the intention being to so place them that they would be safe rom disturbance by caving banks or other causes.

The relative position of the bench-marks is marked approximately on the sketch ıade while the party was ascending the river, and such description of their location ras recorded as it was practicable to make in an uninhabited and almost treeless ountry.

The monuments for the triangulation work were the same as for the bench-marks; xcept that the gas-pipes were 3 feet long and only projected a few inches above ground when set, and the cap on top had a triangular-shaped projection with a small ıole, ½ inch in diameter, drilled in the center. The stones were marked U. S. / △, a small ıole being made in the center.

The method of connecting the permanent bench-marks with the triangulation was y a series of tertiary triangles; the bench-mark lines being made a part of the sysem. This series was connected, as often as was found practicable, directly with the ıain triangulation.

The bench-mark lines, established this season, are numbered consecutively, beginıing at Fort Benton, and the bench-marks are designated thus: P. B. M. $\frac{5}{1}$ is the first ench-mark in line 5 commencing at the right of the line on the right bank of the iver, $\frac{5}{2}$ would be the second mark in the same line.

The levels were to be carried down by the shortest practicable route, from one bench-mark line to another, taking in at least one bench-mark in each line, and to be checked by one level following another, using as a rule the same turning pegs, and making frequent comparisons so as to avoid loss of time in hunting up errors.

Elevations of water-surface were to be taken opposite each bench-mark reached.

It was soon found, however, that the triangulation stations could not be located fast enough to keep two building parties employed; also, that the levelers, working as proposed, could not keep pace with the other work. The parties were, therefore, reorganized by making *one* building party, consisting of a foreman and four men, with a pack horse for carrying the stone, taking one laborer from the bench-mark party and adding one to the party connecting permanent bench-marks and triangulation stations, and dividing the level party into two, adding two laborers to their number, each party to run single lines of levels, leaving them to be checked at some future time, except in cases when the condition of the work happened to be such as to allow time for some portion to be checked. After this, by management, the work proceeded without any great interference, one branch with another, the progress, however, always depending on the rate at which the triangulation stations were located. The pack horse was found to be a wonderful help; the expense was less than $10 per month, and the work accomplished by his use would have required at least two men.

It seems proper in this connection that I should state that, in the early part of March, last, I was requested by the president of the Commission to submit a plan of operations and organization for continuing the survey, commencing the season's work at Fort Benton, the work to embrace a secondary triangulation, establishing permanent bench-marks and their connections with the triangulation and levels as already mentioned.

The plan was submitted March 12, and was approved, in the main, both by the president and secretary, and I was directed to proceed to organize parties for the work in accordance with the plan as approved, and to include the laborers for the triangulation work.

This plan contemplated the carrying on of the triangulation work by an independent party, the observers and their assistants to be provided with a quarter-boat that could be readily navigated by hand and the pioneers, locating triangulation stations, to be furnished a camping outfit, while the triangulation-station building and setting of permanent bench-marks, the material for which had to be carried on the boat, was to be done from the steamer. It also contemplated that the location of triangulation stations would be kept in advance far enough to enable the movements of the steamer and operations of the different parties, for the day, to be planned with some degree of certainty and to allow advantage to be taken of any circumstances to make progress.

The assistant in charge of the triangulation, however, and who also located the triangulation stations, wishing to keep as near as possible to his observers, in order to have their work as much as possible under his eye, thought it best for him to remain with the steamer. This rendered locations for any distance in advance out of the question and necessarily bunched the work to such a degree as often to hamper the movements of the different parties. As an example, on four days in the month of August, only two half-days' work was done, by the building party, for want of locations. This, however, could not be avoided, as it was not possible always, in any one day, to definitely locate a triangulation station, and thus, with all the parties so close together, some one must wait until the question was settled.

The steamboat, which is necessary for transportation of material and supplies, cost, for salaries of crew and for fuel during the months of June, July, August, and September, one-half as much as the salaries of the entire party. It is evident, therefore, that an economical expenditure of money would require from the boat the greatest possible amount of service in a given time, and, in order to do this, its movements must be governed only by the amount of work capable of being done by the parties necessarily attached to it. It seems plain, therefore, that a separate outfit should be provided for the triangulation work that will afford facilities for keeping locations in advance of the steamboat, and also for keeping up necessary communication with the observers. A small steamboat or launch, suited to the navigation of the upper river, could be constructed that would be inexpensive and meet all requirements.

With facilities, as above indicated, for the triangulation party, the work that could be accomplished in a day, from the steamboat, would be limited only by the distance that continuous levels could be carried; and that would be governed, of course, by the force employed at that work. I feel confident that with a party, the monthly expenses of which I estimate at 28 to 30 per cent. greater than that of the past season, at least 50 if not 75 per cent. more work could be done.

The levels, as before stated, were, after the first few days, carried on by two parties, each taking a separate portion of the day's work, the up-stream party, at night, connecting with the bench-mark on which the other party started in the mornig. In this way each party could do about 3 miles of careful leveling in a day. Whenever the other work was delayed for any reason, the levels on that day were checked, both parties going over the same ground. A large portion of that work, therefore, is unchecked, but this, for the purposes of the survey, is not essential at present, as levels must be taken over the whole ground again, when the topographic and hydrographic work is done.

The leveling instruments used, so far on the work, have been 18-inch Y levels, chiefly those manufactured by Buff & Berger, of Boston, with New York rods. The methods used were those usually practiced with these instruments, but great and constant care and several original devices were used to insure accuracy.

Levels were designed, which could be readily attached to the rods for keeping them vertical, and a clamp and tangent screw fitted to the targets to facilitate slight movements.

The instruments, except when being carried from one setting to another, were kept under tents as a protection against sun and wind. The adjustments were examined once a day, or oftener if there were reason to suspect a change. Fore and back sights were equalized by pacing or by stadia measurements, all the instruments having fixed stadia wires, and the rods an extra graduation to correspond. Sights were limited to 300 feet in length except when a longer one was necessary, as in crossing the river. At least three readings of the rod were taken at each sight, which readings must agree within 0.001 feet and a mean of the three adopted. When one level was checking another and discrepancies occurred, on single sights, of 0.006 feet, or more, or discrepancies on single sights of 0.001 per 100 feet of distance between pegs, if pegs were more than 300 feet apart, a repetition of the work was required. The rodman was required to keep full notes, as a check; and in order that the reductions should be as nearly independent of each other as possible, and the time, used in calculations in the field, reduced to the minimum, the following system was required to be invariably used: The rodman, being at a bench or peg, and, having given three settings of the target that answer the requirements, reduced them to a mean and recorded the same, sets the target at the mean reading, clamping it firmly; as he then approaches the instrument, the leveler calls the elevation of the bench or peg the rodman has just left, which the rodman halts to compare with his own record, at the same time presenting his rod to be read by the leveler, who examines it and calls out the last three figures of the reading, which the rodman also verifies, by reference to his book, and then passes on to the next peg. Here, after having given the three rod readings in the same manner as before, made his record, and set his target, he calculates the last height of instrument, the data for which he has already, while the instrument is coming up, and, as the leveler approaches the peg, calls this height of instrument, which the leveler verifies by reference to his note-book and then checks the last rod reading, as before, by calling out the last three figures, and so on.

In crossing the river, when found necessary, a similar method of procedure to that required by General Comstock for "ordinary levels," in his "Instructions for the Survey of the Mississippi River," in 1878, was used. The instrument being set upon the shore, and quite close to the last turning peg, two or three careful readings are taken on the peg, then eight to twelve readings on a peg across the river, a mean of which is taken as the true reading. The instrument is then moved across the river and the process reversed, eight to twelve readings being taken on the peg across the river and then two or three on the one near the instrument. General Comstock states that, for a river 1,460 feet wide, this method has given results with a probable error of less than 0.0007 foot.

In 1880 and 1881, levels were run between Sioux City, Iowa, and the mouth of the river, in two continuous lines, one starting from Sioux City, the other from Lexington, Mo. These were checked by independent levels running into the same benches. The greatest difference found between the two lines from Sioux City to Lexington was 0.182 foot, 472 miles below Sioux City. From Lexington to the mouth the greatest difference was 0.173 foot, 200 miles below Lexington.

Levels were also carried from Fort Randall to Sioux City (179 miles) in 1881, and checked in the same manner. The difference in elevation at the end of the line was 0.060 foot. The greatest difference at any time was 0.082 foot, at 128 miles.

In 1882, 190 miles of levels were run (Pierre, Dak., to Fort Randall), where the difference was 0'.154, the greatest difference being 0.156 foot, at 175 miles.

In 1885, the greatest length of continuous checked line was 17 miles; difference, 0.021 foot.

All these differences are considerably within the limit of error allowed by the Mississippi Commission.

It will be readily seen that such a coincidence of results must necessitate the most careful manipulation of the instrument, as well as a rigid adherence to systematic methods of procedure, by both parties. If, then, the Y level is capable of precise work, the good quality of that done on this survey must be admitted.

As some question has arisen as to the confidence that can be placed in these levels, the above details are given.

The leveling this season was under the special charge of Assistant Albert Warren, to whose care, zeal, and energy I am greatly indebted.

The level work in the fall of 1884 was simply transferring elevations from benches formerly established to the permanent bench-marks.

I would state here that the rather meager results of that season's work were due

to the inadequate force employed. The work was new, and the difficulties were not known until operations commenced. It was then so near the end of the season, estimated to be less than a month, that it was not thought best to attempt any change.

For carrying on the work on the portions of the river where the bluffs are timbered an entirely different organization is required from that needed where they are bare, as is the case from Yankton to Fort Benton.

Considerable damage was done the past season to the steamboat Missouri, her light machinery rendering it impossible to handle her on the rapids and to keep her off the rocks, with which the bottom in these places is covered, and which indeed abound in the upper 300 miles of the river, while, on account of the light build of her hull, if a rock is touched a hole in her bottom is almost sure to result.

On August 17 a hole, which took two days to repair temporarily, was stove in her bottom from this cause, and several floor timbers and bottom plank were broken, and before the rapids were passed more than forty floor timbers were broken and several more plank shattered. River-men consider it a piece of remarkable good fortune that she was gotten through at all. The boats running regularly in that part of the river are strongly built, with powerful machinery, with which they can be readily handled, and while they cannot be kept off the rocks entirely, their strength prevents much damage.

It is estimated that at least $2,000 will have to be spent in repairs on the Missouri before she will again be fit for service. The season's experience has demonstrated her unsuitableness for the work on the upper river, both on account of expenses for repairs, which are almost inevitable, and from the time lost when it is necessary to go up stream. Thirty days were consumed in June and July last in going from Bismarck to Fort Benton, an estimated distance of 816 miles, during which time the entire party were under pay, a large share of them doing nothing except to assist in getting the boat along by pulling on a tow-line. The running time was not less than sixteen hours a day. This would make an average speed of 1.7 miles per hour. The boat will answer quite well for the triangulation and bench-mark work yet to be done, as in that part of the river there is less current, and the bottom is principally sand; but for that still to come in the upper river a strongly built and powerful boat is needed. A suitable boat for this purpose would be a good tow-boat for improvement work when the survey shall be completed.

For continuing the triangulation and permanent bench-mark work on the basis of the plan herein outlined an organization something like the following would be needed: Two parties building triangulation stations; one party setting permanent bench-marks; one party connecting permanent bench-marks with triangulation stations, and three level parties.

This would require a force of 56 to 58 men all told, the monthly salaries amounting to about $3,000. Total monthly expense, including subsistence and fuel, $4,000 to $4,500.

Very respectfully, your obedient servant,

D. W. WELLMAN,
Assistant Engineer.

Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

APPENDIX A 3*b*.

FIELD WORK IN MONTANA.

On June 4 the observers and myself arrived at Bismarck, and on the 5th 3 rodmen and 7 laborers reported for field work in Montana.

The party arrived at Benton, on board the United States steamer Missouri, on the evening of July 4. While the quarter-boat, brought from Saint Louis in parts, was being put together a base-line was selected and measured three times over, and its azimuth determined by three nights' observation on Polaris near elongation. Five stations were located on the main triangulation, and the base-line stations were connected by tertiary triangulation with the flag-staff of Fort Benton, the latitude and longitude of which is reported in Major Twining's "Report on the Northern Boundary Survey," 1878, pages 193 and 399, as latitude 47° 48′ 50″, longitude 110° 39′ 48″. Connections were also made with land surveys and other points.

The quarter-boat was turned over to the party on July 20, and the parties, as then organized, were a reconnoitering party consisting of myself, a rodman, and a boatman, to work mainly from the steamer Missouri; two observing parties, one for each

bank, to work from the quarter-boat, each party consisting of an assistant engineer, rodman, and three laborers; while a mate, two boatmen, and a cook remained on the quarter-boat, or took the place of laborers in the observing parties when required. The instruments were the same as used in the lower work, but large tripods were substituted for stations and large umbrellas for observing tents. The tripods were made in Saint Louis, from designs principally by Mr. Humphreys. (See photographs 254 and 256.) The trivet-plate was made movable, for the purpose of centering over the station mark, and the tripods were a complete success, both for convenience and stability. The targets were concentrically secured to the cap of the iron pipe which marks the place of the station, and were placed by the station-building party. When a station was being occupied the target was set aside and a smaller one sighted in for the use of the other observing party. The larger target-frame was 6 feet in height by 9 inches in diameter, and the smaller one was rectangular, 30 inches in height by 7 inches in width.

The first stations off the Benton base were occupied on July 21, and the last to close on Trover's Point base on September 30, on which date the field work was closed. The Trover's Point base was measured three times over; its azimuth determined by three nights' observations on stars near elongation, and its approximate latitude determined.

There were sixty-two working days, of which two were too rainy, seven too smoky, and one too windy for angle reading; leaving fifty-two days on which it was possible to occupy stations.

There were ninety-four stations occupied (besides four located outside the system), and thirty-five cases in which stations were reoccupied, caused by the mistaking of or by the invisibility of a target or by a shower of rain before the day's work was completed. In a few cases stations were reoccupied because the triangle did not close within limits, and this took much time, when it was necessary to row up-stream from 3 to 5 miles. The number of triangles measured was 200, giving 52 quadrilaterals. The axillary length of the net was 177 miles. On several occasions a party was able to complete two stations a day, but this cannot well be done on many consecutive days, for if the parties leave the quarter-boat at dawn they cannot well be at the boat again before 10 or 11 a. m., having from a half mile to 2 miles to carry boxes, read angles, make sketches, &c. It requires an hour to reduce and compare results on the upper triangles before it is safe to drop the quarter-boat down-stream. It then takes two hours to drop down-stream by quarter-boat, or about one hour to row down by skiff to reach the landing for the next station. It is 3 p. m. by the time the station is reached, and dusk by the time the parties are again at the quarter boat; then results must be compared, and there is no time left for dropping down, so as to leave for a station at dawn the next morning.

It is noticed that a. m. observations are more discordant than those of p. m., and that, in general, it is next to impossible to make satisfactory observations in the middle of a sunshiny day. The most satisfactory work is done after 3 p. m., and it is probable that there is nothing gained by an observer trying to occupy more than one station a day when the quadrilaterals are from 3 to 5 miles in length and the bluffs so high and rugged as those of the Upper Missouri.

The country in general may be described as a treeless, grassy, alkaline plain, through which run numerous dikes and an occasional mountain ridge. The Missouri River and its tributaries have eroded the surface and left innumerable cañons, with abrupt rocky bluffs, from 200 to 1,100 feet in height. The rock is mostly of a soft sandstone, cut with iron-stone dikes, and a clayey shale of great depth underlies the sandstone. Veins of impure soft coal and red scoria are frequently present. Cottonwood and willows grow on the narrow bottom land, and between Judith and Old Fort Peck, much pine, spruce, and red cedar are found in the cañons and on the hill sides. In the disintegrated shale bluffs there are many land slides, which when wet with spring rains are almost impassable. There was much rain this season up to the middle of July, but during August and September there was very little, and the season was favorable for our work. October would also have been a favorable month for work.

The party arrived at Bismarck by steamer on October 15, and were discharged. On the way to Bismarck an accurate plot was made of the net of triangles checked by the closing of the Benton base on the Trover's Point base, both in length of line and in the proper change of azimuth.

On return to this office it was decided, in order to find the length of the base line tape, to remeasure, under as nearly as possible the same tension and conditions as actually existed in the field, a portion of the Olney base, primary 1879. (See Professional Papers, Corps of Engineers, No. 24.) The portion selected was the east half, or a distance of 2.05 miles, which was twice measured in an overcast day.

The Glasgow base, located a year ago, was then measured twice over, and its azimuth determined by two nights' observations on stars near elongation, which closed the field work on November 11.

THE BASE-LINE MEASUREMENTS.

The experience of observers, under the Mississippi River Commission, on base-line measurements with a steel-tape had not been entirely satisfactory; but it was believed that the main source of error was due to an uncertain temperature correction. Accordingly I determined to do this work by night or on an overcast day and in the quickest time possible, that single measurements might be comparable, the change of temperature being slight during a measurement.

The apparatus prepared was (see Plate II) slow-motion screws, for controlling ends of tape; tension apparatus, to give a known strain on tape; wire hooks, to support tape and eliminate friction, and zinc strips, for the marking stakes, for permanent record. The screws were of wood, three-fourths of an inch in diameter, and prepared from common carpenter's wood clamps. The socket block of that used at the rear end of tape was supported on a straining-stake, being held to the stake by two sharp spikes in the block and by a wire about 3 feet long, attached to the block and to an iron pin, which pin was pressed in the ground to the rear of the straining-stake. The nut was attached to the tape through wire links, by means of which a first rough adjustment was made. The socket block of the screw, at the front end of the tape, was fastened to a table, and the nut carried a slide in grooves, which slide carried an iron fulcrum piece for a knife-edge. The table was a plank, 2 inches by 8¼ inches by 18 inches, supported on three stakes, and held to the stakes by sharp spikes in its bottom. The lever arm-piece was of wood, 8¼ by 8¼ inches, an inch thick at top, 2 inches at bottom, and lightened by having the front upper corner cut away. The knife blade was set in the lower rear corner, at an angle of 45° with the side; it was longer than the thickness of the block, and the projections gave the bearings on the iron fulcrum. The sides of the block from the knife-edge corner gave the lever-arms, each exactly equal in length and at right angles to each other. A spirit level was attached to the upper edge of the block and made parallel with horizontal lever arm. A weight, consisting of a can of shot, was made exact by placing it, together with hook end of the horizontal arm, on the scales, while the knife-edge end of the arm rested in the fulcrum, and was to give a known tension of 16 pounds to the tape. An engraver's pencil and a right-angled rule, of the same width as the zinc strip, was used in marking on the zinc strips. The thermometers were attached to stiff wire stakes for easy and safe transportation, and were so set that the bulb was at about the elevation of the tape above the ground. The wire hooks, for supporting the tape, were 2 inches in length (No. 12 wire), and so made that the planes of the hooks at the ends were at right angles to each other

The base line was cleared of brush and weeds and about 400 stakes, each 3 feet in length, with a cross-section of about 4 square inches, cut from young cotton-wood trees, or sawed and split from larger trees, were distributed over the line. The marking stakes were set in line, with a field transit at every tape length and spaced with the tape under a stretch by spring balance of 16 pounds, and were driven to about 20 inches above ground, when a zinc strip, made parallel with the stretched tape, was tacked on the top. The three table stakes, about 3 feet in advance, and the straining stake, about 3 feet in the rear of the marking stake, were adjusted in position and height by a test frame, the table stakes being 11½ inches below and the straining stakes 2 inches below the marking stake, so that the tape when stretched was barely in contact with the zinc strips. The supporting stakes at every 30-foot graduation of the tape were also distributed by the party of four setting the marking stakes. Another party of two attended to setting in the supporting stakes and putting in line for each tape length the nails driven, nearly horizontally in the supporting stakes, at a height of 2 inches above the line of the tops of the marking stakes. The heads of the nails were brought in line, vertically and otherwise, by eye, the heads of the nails being a trifle lower than the points, so that the bearing of the hooks should be against the nail head. A party of two ran a line of check levels over the marking stakes.

To make a quick measurement requires a party of sixteen persons, distributed as follows: An observer and assistant at rear end of tape; an observer, assistant, and attendant at front end; nine persons at the supporting stakes, two of whom can read thermometers reliably; a recorder and the chief of party as superintendent.

When ready for measurement the observers exchange word signals, as follows: The rear observer, as soon as he notices that the weight has been applied, adjusts approximately and calls out "ready." The front observer replies "ready." The rear observer shouts "mark," and the front observer shouts "marked." Then the thermometer readings are called out and recorded, the time and weather conditions noted, and all make ready to march except the front observer, who makes and numbers a line, with an engraver's pencil and rule, on the zinc at right angles to the base line from an indentation already made by the pencil. When the front observer is ready he takes the end of the tape and orders "march." All move rapidly forward, each man from a supporting stake, carrying the hook, with the tape in place ready to replace it on its proper stake. The superintendent takes care that there is no twist in the tape, &c.

When there is day-light for the work it is possible to measure a tape length every two minutes; by lamp-light about one-third more time is required. On two occasions this season 32 tapes, or 1.85 miles, were measured in one hour and nine minutes. Second and third measurements are so numbered on the zinc strips. The zinc strips are of such length as to give some room for expansion in the tape, but it is sometimes necessary to make a set-back or a set-ahead at the rear zinc. The difference of measurement, as shown on the zinc strips, is read to the nearest one-hundredth of an inch before the strips are taken from the stakes. The strips are then numbered and kept as a part of the record of measurement.

There has been a remarkably close agreement in two or three measurements of the same line, in three of the four base lines this agreement being less than 1 in 400,000 when reduced to 62° Fahr.

THE READING OF ANGLES AND REDUCTION OF TRIANGULATION.

The theodolites used were the 10-inch limb non-repeaters, Troughton and Simms's, Nos. 1 and 2, made expressly for the Mississippi River Commission, in which the circle is clamped to the axis and is revolvable on it when unclamped.

The method of reading angles was that given in Professional Papers, Corps of Engineers, United States Army, No. 24, page 31, under (c), and eight combined results were obtained as giving a weight-unity to an angle. The closing of the horizon was avoided, however (in order to simplify the reduction), by stopping on the last station and not "closing on the first."

The method of reduction will be that given for a single quadrilateral, by Col. A. F. Clark, "Geodesy," pages 263–6, except in two cases in getting off bases, when the method given by General Comstock (Professional Papers, No. 24, pages 306–312) will be followed.

AZIMUTH.

The observations were made in accordance with the method given in Professional Papers, No. 24, pages 29, 30.

The alternate pointings on some stars were lowered to the image from an artificial horizon, so as to eliminate the level correction. The reduction will be by formulæ given on page 640 of Professional Papers, No. 24.

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, Secretary Missouri River Commission.

APPENDIX A 3c.

LENGTH OF BASE LINE.

The lengths of the base lines, measured during the season of 1885, are expressed by the following equations:

BENTON BASE.

(1) $33\times 299'.079\pm 000'.000+0'.975-1'.809\pm 0'.000-0'.180+1'.711=9870'.304.$
(2) $33\times 299'.079\pm 0'.000+0'.795\pm 0'.000\pm 0'.000-0'.180+0'.221=9870'.443.$
(3) $33\times 299'.079\pm 0'.000+0'.928+0'.250\pm 0'.000-0'.180-0'.217=9870'.388.$

TROVER'S POINT BASE.

(1) $32\times 299'.079+140'.033+1'.662\pm 0'.000\pm 0'.000-0'.240-0'.067=9711'.916.$
(2) $32\times 299'.079+140'.033+1'.662\pm 0'.000-0'.120-0'.240+0'.052=9711'.915.$
(3) $32\times 299'.079+140'.033+1'.662\pm 0'.000+0'.628-0'.240-0'.719=9711'.892.$

In which equations the terms are:

First term. Number of entire tapes multiplied by length of tape at 62° Fahr.

Second term. A distance measured with a fractional part of the tape under 16 pounds tension and reduced to 62° Fahr. between the last and the next to the last marking stakes of the base line.

Third term. A distance measured with a boxwood scale between this last stake and the end of the base line.

Fourth term. Total distance set back or ahead on a measurement as recorded on the zinc strips. (See tables appended.)

Fifth term. Reduction of one measurement to another, as shown by record from zinc strips. (See tables appended.)

Sixth term. Inclination-of tape correction. (See tables appended.)

Seventh term. Temperature correction to reduce distances by tape, at tape temperature, to 62° Fahr. (see temperature tables);

and the second member is the corrected length of base line for each measurement.

DISCUSSION OF RESULTS.

Benton base.—The mean of the three wholly independent measurements=9870′.378. The mean of the second and third=9870′.415, giving a difference of about four one-hundreths of a foot.

But the first measurement was rejected in the field, owing to the high and uncertain temperature of the tape when working in the sun over heated ground, and to the fact that it was made principally for practice as the first application of the method. (See note under table of temperatures.)

The mean of the second and third, then, is taken as the true result and its probable error is, from the results themselves, $\pm 0'.0185$ and this (the usual standard of comparison) is 1 in 533,000.

Adopted Benton base at its own elevation above sea level =9870′.415.

Trover's Point base.—The mean of the three measurements (independent for 32 tapes)=9711′.908. The mean of the second and third measurements=9711.904, giving a difference of four one-thousandths of a foot, or the two are, for all practical purposes, identical.

But the first measurement was incidentally made while setting the zinc strips during a large change of temperature, as shown by only one thermometer, and that the uncompared one. (See tables of temperature.) Also, there were but six persons to assist the observer and the time taken was large, 2½ hours.

The mean of the second and third is then taken as the true result and its probable error from the results themselves=$\pm 0'.0078$, or one in 1,250,000 parts of the base.

Adopted Trover's Point base at its own elevation above sea level = 9711′.904.

OLNEY BASE.

Determination of one tape-length at 62° *Fahr.*—The value of one tape-length (l) from 0 graduation to the 299-foot graduation is twice determined from the following equations, where the terms are as before described:

$$(1)\quad 36\,l+\frac{l+1\text{ foot}}{6}+4'.327+1'.500-0'.133-0'.126-0'.489=10821'.9662.$$

$$(2)\quad 36\,l+\frac{l+1\text{ foot}}{6}+4'.327+1'.498\pm 0'.000-0'.126-0'.618=10821'.9662.$$

from which, by transposing the known quantities, we have—

$$(1)\ 36\tfrac{1}{6}\,l=10816'.720\ \text{ or }\ l=299'.0799$$
$$(2)\ 36\tfrac{1}{6}\,l=10816'.718\ \text{ or }\ l=299'.0798$$

$$\text{Mean } l=299'.07985$$

To this mean it is necessary to apply a minus correction of 0′.00085, or one in 350,000, due to the fact that the horizontal lever-arm was inadvertently lengthened by the tenth of an inch in the following manner. The bail of the weight-can had been made more secure by a smaller wire, and this wire was used in suspending the can in the former base measurements. The person carrying the can and suspending it on its hook at the Olney base used the larger lower wire, the centre of which was crowded out by the block (see drawing) farther than the bearing of the smaller wire by 0″.10 by actual measurement.

The adopted value for one tape-length = 299′.079 at 62° Fahr. On the tape is a standard *as graduated* under a 16 pounds tension at 24½° Fahr., or under a tension of 1¼ pounds at 62° Fahr. (using co-efficient of expansion = 0.000007 for 1° Fahr., and extension of tape = 0′.00538 for one pound tension, as given from the office of the Mississippi River Commission for this same tape.)

The mean error of the adopted result is not greater than $\pm 0.'0005$ or the probable error not greater than $\pm 0'.00034$.

NOTE.—The seventh term in the above equations contains the temperature correction for the first and second terms, and the second member is the known value of the east part of the Olney Base. (See page 303 of Professional Papers, Corps of Engineers, No. 24.)

Adopted value on tape length $= 299'.079 \pm 0'.00034$ at 62° Fahr., under 16 pounds tension.

The tape is accurately subdivided, as shown by part tape measurements, the above six portions (50′ each) differing by only 0″.02 in the extreme.

COMPARISON OF STANDARD TAPE WITH 299 FEET OF THE 500-FOOT TAPE.

Two sets of comparisons of a portion of the 500-foot tape with the standard tape were made on July 10 and September 28, of which the results were identical.

The length of this portion from zero to a filed mark in tape near the 300-foot graduation is $= 299'.082$, and from zero to cut in solder, at 300-foot graduation, is $= 300'.082$ (each under a tension of 16 pounds at 62 Fahr.) The *filed* mark and *cut* in solder are one foot apart by boxwood scale measurement.

Respectfully submitted.

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Assistant Engineer.

First Lieut. T. A. BINGHAM,
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Secretary Missouri River Commission.

APPENDIX A 3d.

MEASUREMENTS OF THE BENTON BASE.

The three measurements of the Benton Base are expressed by the following equations:

(1) $33 \times 299'.079 - 1'.809 - 0'.180 + 0'.975 + 1'.711 = 9870'.304.$
(2) $33 \times 299'.079 - 0'.000 - 0'.180 + 0'.795 + 0'.221 = 9870'.443.$
(3) $33 \times 299'.079 + 0'.250 - 0'.180 + 0'.928 - 0'.217 = 9870'.388.$

First term is number of tapes multiplied by length of tape at 62° Fah.

Second term is sum of distances set forward or backward on zincs.

Third term is inclination-of-tape correction.

Fourth term is distance between mark on zinc 33 and △ West Base.

Fifth term is temperature correction to reduce 33 tapes, at tape temperature, to 62° Fah., and the second member is the corrected independent result for each measurement.

The mean of the three measurements is $= 9870'.378$; the mean of the second and third measurements is $= 9870'.415$, giving a difference of about four one-hundredths of a foot. But the first measurement was rejected in the field. (See note under the table of temperatures.)

The mean of the second and third is then taken as the true result.

The probable error of this result, from the individual results, is $= \pm 0'.0185$, or one in 533,000 parts of the base.

Benton Base, at its own elevation above sea-level $= 9370'.415$.

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A., Secretary Missouri River Commission.

Temperatures of Benton Base.

No. of tape.	First measurement.			Second measurement.			Third measurement.		
	July 10, 1885. Time.	Thermometers.		July 11, 1885. Time.	Thermometers.		July 11, 1885. Time.	Thermometers.	
		G.	H.		G.	H.		G.	H.
	P. M.	° F.	° F.	P. M.	° F.	° F.	P. M.	° F.	° F.
1	2 15	87	89	7 37	68.5	69	9 29	64	64.5
2	19	88	89.5	43½	68	68.5	31	63.5	64
3	21	86.5	87.5	46	68.5	69.5	34½	63	63
4	24	87	88.5	48	69	69.5	37½	62	63
5	27	85.5	88	50	69	69.5	39½	61.5	62
6	35	88	88.5	52	69	69.5	44	61	62
7	39	88	88.5	54	68	68.5	46	61.5	62
8	42	87.5	90	56	67.5	68	49	61.5	62
9	44	87.5	88.5	58	68	68.5	51	62	62
10	47½	88	89	8 00½	67.5	68.5	54½	61.5	62
11	50	89.5	89.5	02½	68	69	57	61	61.5
12	53	88.5	90	05	68	69	59	61.5	62
13	56½	88	89.5	07	68	68	10 01½	61	61.5
14	3 00	88	90	08½	68	68.5	04	61	61
15	04	89	89	10	67	68	06½	61	61
16	11½	88.5	90.5	12½	67	68	09	60	61
17	15	88	90	14½	67	67.5	11	61	61
18	18	89	90	17	66.5	67.5	14	60	60.5
19	21	90.5	90	19	66	67	16½	60.5	60
20	24	90	91	21	66	66.5	19	60	60
21	26½	89	90.5	23	66	66.5	21½	59	59.5
22	30	89	88.5	24½	66	66.5	25	58	59
23	36	86	87	26½	65	66	36	59	59.5
24	40	86	86	28½	64.5	65	40	58	59
25	43	87	88	30½	64	64	42	59	59
26	46	86.5	87.5	32½	64	64	44	59	59.5
27	49	86.5	87	34½	63.5	64	47	58	59
28	53	86.5	87.5	36½	63.5	64	49½	59	[illegible]
29	56	87	87.5	38½	63	63.5	52	58	[illegible]
30	59	86	87.5	40	63.5	64	55	57.5	58
31	4 01½	85.5	86	42	64	64.5	57½	57	57.5
32	04	85	86.5	43½	64	63	11 00	56	57
33	08½	89	89	45½	65	66	03	56	57
Means		85 87.58	120 88.64		210.5 66.38	231.0 67		1.0 60.03	17.0 60.52
Corrected		—.80			—1.17			—1.18	
Corr. means		86.78			65.21			58.85	

NOTE.—G is a compared thermometer of the Mississippi River Commission, and H is an uncompared thermometer, graduated only to 2° intervals, belonging to Mr. Humphreys.

The first measurement was made with the thermometers uncovered and in the sun, in the afternoon of a warm day, when the ground was very much heated. It was noticed that in carrying the thermometers at a higher elevation, in passing from one stake to the next, the mercury usually fell about two degrees. This measurement was also in part for practice, and no weight is given to it in the final result.

The second measurement was begun late in the afternoon of a cooler, somewhat hazy day, and finished without the aid of lamps.

The third measurement was made on the same evening, but entirely by lamp-light. The wind during second and third measurements was very slight, almost a calm, and from the west, or in the direction of the base line.

Correction for inclination of tape on Fort Benton Base.

[l=length of tape; $\sin i=\frac{h}{l}$; correction=ver sin $i\times l$; i=angle of inclination; h=difference of elevation.]

No. of stake.	Elevation.	Difference of elevation.	Log difference elevation. Log h.	Log h − log l = log sin i.	i.		Log ver sin i.	Log ver sin i + log l = log correction.	Correction.
	′	′			′	″			′
△ E. B.	100.0	....	....	....	....	....	....	....	....
Zinc. 0	101.5	1.5	....	....	....	....	....	....	....
1	101.2	0.3	9.47712	7.00130	03	26	3.58066	6.05618	0.0001
2	101.7	0.5	9.69897	7.22315	5	44	4.18273	6.65855	0.0005
3	98.9	2.8	0.44716	7.97134	32	10	5.63072	8.11254	0.0130
4	98.2	0.7	9.84510	7.36928	8	02	4.43260	6.90842	0.0008
5	96.7	1.5	0.17609	7.70027	17	14	5.08732	7.56314	0.0037
6	95.0	1.7	0.23045	7.75403	19	32	5.22848	7.70430	0.0051
7	93.1	1.9	0.27875	7.80293	21	50	5.31127	7.78709	0.0061
8	90.7	2.4	0.38021	7.90439	27	32	5.52074	7.99656	0.0099
9	89.8	0.9	9.95424	7.47842	10	20	4.62642	7.10224	0.0013
10	89.2	0.6	9.77815	7.30233	6	54	4.31662	6.79244	0.0006
11	90.0	0.8	9.90309	7.42727	9	12	4.53191	7.01073	0.0010
12	94.3	4.3	0.63347	8.15765	49	26	6.00681	8.48263	0.0304
13	91.9	2.4	0.38021	7.90439	27	36	5.52074	7.99656	0.0099
14	92.2	0.3	9.47712	7.00130	3	26	3.58066	6.05648	0.0001
15	92.5	0.3	9.47712	7.00130	3	26	3.58066	6.05648	0.0001
16	92.1	0.4	9.60206	7.12624	4	36	4.02436	6.50018	0.0003
17	90.5	1.6	0.20412	7.72830	18	24	5.13697	7.61279	0.0041
18	92.0	1.5	0.17609	7.70027	17	14	5.08732	7.56314	0.0037
19	93.1	1.1	0.04139	7.56557	12	28	4.78478	7.26060	0.0018
20	92.6	0.5	9.69897	7.22315	5	44	4.18272	6.65854	0.0005
21	92.2	0.4	9.60206	7.12624	4	36	4.02436	6.50018	0.0003
22	90.8	1.4	0.14613	7.67031	16	06	5.03466	7.51048	0.0032
23	88.7	2.1	0.32222	7.84640	24	08	5.38684	7.86266	0.0073
24	85.0	3.7	0.56820	8.09238	42	32	5.89353	8.36935	0.0231
25	88.6	3.6	0.55630	8.08048	41	42	5.87291	8.34873	0.0223
26	91.3	2.7	0.43136	7.95554	31	02	5.60914	8.08496	0.0122
27	89.7	1.6	0.20412	7.72830	18	24	5.13697	7.61279	0.0041
28	86.8	2.9	0.46240	7.98658	33	20	5.66345	8.13927	0.0138
29	86.8	0.0	....	....	....	....	....	....	....
30	86.4	0.4	9.60206	7.12624	4	36	4.02436	6.50018	0.0003
31	86.1	0.3	9.47712	7.00130	3	26	3.58066	6.05648	0.0001
32	86.3	0.2	9.30103	6.82521	2	18	3.22848	5.70430	0.0001
33	86.1	0.2	9.30103	6.82521	2	18	3.22848	5.70430	0.0001
W. B. △	84.7	....	....	....	....	....	....	....	....
									−0.1802

Measurement of the differences at end of each tape, Benton Base Line

[The second measurement is taken as a standard, and the differences, as recorded are taken as corrections to the first and third measurements.]

No. of tapes.	Second measurement—first measurement.			Second measurement—third measurement.		
	Readings on zinc.	Correction.	Reduced.	Readings on zinc.	Correction.	Reduced.
	"	"	"	"	"	"
1	−0.53	....	−0.53	+0.12	....	+0.12
2	−1.09	....	−1.09	+0.23	....	+0.23
3	−1.59	....	−1.59	−2.61	§+3.00	+0.39
4	−2.12	....	−2.12	−2.45	....	+0.55
5	−2.62	....	−2.62	−2.33	....	+0.67
6	−0.04	−3.21*	−3.25	−2.13	....	+0.87
7	−0.59	....	−3.80	−1.95	....	+1.05
8	−1.18	....	−4.39	−1.82	....	+1.18
9	−1.18	....	−4.99	−1.68	....	+1.32
10	−2.29	....	−5.50	−1.52	....	+1.48
11	−2.93	....	−6.14	−1.38	....	+1.62
12	−3.57	....	−6.78	−1.24	....	+1.76
13	−4.22	....	−7.43	−1.14	....	+1.86
14	−4.86	....	−8.07	−0.98	....	+2.02
15	−5.54	....	−8.75	−0.87	....	+2.13
16	+1.32	†−10.71	−9.39	−0.72	....	+2.28
17	+0.71	....	−10.00	−0.60	....	+2.40
18	+0.06	....	−10.75	−0.46	....	+2.54
19	−0.60	....	−11.31	−0.31	....	+2.69
20	−1.30	....	−12.00	−0.15	....	+2.85
21	−1.86	....	−12.57	0.00	....	+3.00
22	−2.47	....	−13.18	+0.17	....	+3.17
23	−3.03	....	−13.74	+0.39	....	+3.39
24	−3.58	....	−14.29	+0.40	....	+3.40
25	−4.20	....	−14.91	+0.49	....	+3.49
26	−4.76	....	−15.47	+0.59	....	+3.59
27	−5.35	....	−16.06	+0.70	....	+3.70
28	+5.08	‡−21.71	−16.63	+0.77	....	+3.77
29	+4.45	....	−17.26	+0.96	....	+3.96
30	+3.91	....	−17.80	+1.10	....	+4.10
31	+3.35	....	−18.36	+1.24	....	+4.24
32	+2.77	....	−18.94	+1.41	....	+4.41
33	+2.12	....	−19.59	+1.58	....	+4.58

*Set back 3".21 on zinc No. 5, first measurement.
†Set back 7".50 on zinc No. 15, first measurement.
‡Set back 11".00 on zinc No. 27, first measurement.
§Set ahead 3".00 on zinc No. 2, third measurement.

APPENDIX A 3e.

MEASUREMENTS OF THE TROVER'S POINT BASE.

The three measurements of the Trover's Point Base are expressed by the following equations:

$$(1)\quad 32 \times 299'.079 + 140'.033 + 1'.662 \pm 0'.000 - 0'.240 - 0'.067 = 9711'.916.$$
$$(2)\quad 32 \times 299'.079 + 140'.033 + 1'.662 - 0'.120 - 0'.240 + 0'.052 = 9711'.915.$$
$$(3)\quad 32 \times 299'.079 + 140'.033 + 1'.662 + 0'.628 - 0'.240 - 0'.719 = 9711'.892.$$

Where

First term. Is number of entire tapes multiplied by length of tape at 62° Fahr.

Second term. Is distance from first measurement mark on zinc 32 to full mark on zinc 33, as measured in parts of tape under 16 pounds tension.

Third term. Is distance from full mark on zinc 33 to △ west base, as measured with a boxwood scale.

Fourth term. Is correction to reduce second and third measurements to the first, as shown on zinc 32.

Fifth term. Is inclination-of-tape correction.

Sixth term. Is temperature correction to reduce 32 tapes, at tape temperature, to

62° Fahr.; and the second number is the corrected result for each measurement. The second term is computed from the following data:

No. of measure—0 of tape at first measure mark on zinc 32.	Time—Sept. 28, a. m.	Thermometer G.	Thermometer H.	140 grad. falls behind or ahead of full mark on zinc 33.
	h. m.			″
1	8 45	59° in shade	60° in shade	0.000.
2		64° in sun	66° in sun	.010 behind.
3		61°.5 in shade	61° in shade	.035 ahead.
4		63° in shade	62° in shade	.065 ahead.
5		65° in shade	64° in shade	.090 ahead.
6	9 10	66° in shade	70° in sun	.080 ahead.
7	9 13	66°.5 in shade	70° in sun	.090 ahead.
8	9 17	66° in shade	70° in sun	.100 ahead.
Mean				0″.056 = 0′.005.

140 grad. at first measure mark on zinc 32.	Time—Sept. 28, a. m.	Thermometer G.	Thermometer H.	280 grad. ahead of full mark on zinc 33.
	h. m.			″
1	9 25	67° in shade	72° in sun	0.185 ahead.
2	9 30	66° in shade	71° in sun	.165 ahead.
3	9 35	66°.5 in shade	71°.5 in sun	.175 ahead.
4	9 37	67° in shade	71° in sun	.190 ahead.
5	9 40	67° in shade	70° in sun	.170 ahead.
6	9 42	66°.75 in shade	70° in sun	.160 ahead.
Mean				0″.174 = 0′.014.

Since the tape was in the sun it is best to use the observations on the standard thermometer (G) reducing those "in shade" to "in sun" by applying a plus correction of from two to three degrees for the first series, and four degrees for the second series. We then have, with sufficient accuracy, for this 140 feet of tape (after applying a minus correction of one degree for error of thermometer), 65° for the temperature of tape for first series, and 70° for that of second series, and the minus correction, to reduce to 62°, is 0′.003 for first series, and 0′.008 for second series, which, applied to the means in the last column, reduces them to 0′.002 for first series, and 0′.006 for second series. We have then the distance between first measurement mark on zinc 32, and full mark on zinc 33. For first series

$$\left(\frac{140}{299}\times 299'.079\right)-0'.002=140'.037-0'.002=140'.035$$

and for second series

$$\left(\frac{140}{299}\times 299'.079\right)-0'.006=140'.037-0'.006=140'.031$$

The mean of these gives 140′.033 for the second term in the equation. The mean of the three measurements (independent for 32 tapes) = 9711′.908; the mean of the second and third measurements = 9711′.904, giving a difference of four one-thousandths of a foot, or the two are, for all practical purposes, identical.

But the first measurement was incidentally made while setting the zinc strips during a large change of temperature as shown by one thermometer, and that the uncompared one (see table of temperatures); also there were but six persons to assist the observer and the time taken was large, 2¼ hours.

The mean of the second and third is then taken as the true result, and its probable error from the results themselves = ± 0′.0078 or one in 1,250,000 parts of the base.

Trover's Point Base at its own elevation above sea level = 9711′.904.

Temperatures of Trover's Point Base.

No. of tape.	First measurement.*			Second measurement.			Third measurement.		
	September 26, 1885. Time.	Thermometers.		September 28, 1885. Time.	Thermometers.		September 28, 1885. Time.	Thermometers.	
		H.	G.		G.	H.		G.	H.
	P. M.	° F.		P. M.	° F.	° F.	P. M.	° F.	° F.
1	....	72	....	4 20	65.5	66.5	6 16½	53.5	52.5
2	....	71	....	21½	65	66	20	54	53
3	....	70	....	25	65	65.5	25	53	53
4	....	70	....	27	64.5	65.5	27½	52.5	52
5	4 30	71	....	29	64.5	66	31	51.5	51
6	....	71	....	31	65	66	34	54	54
7	....	70	....	34	65.5	66.5	37	54.5	54
8	....	70	....	36	65.5	66	39	53.5	53.5
9	....	68.5	....	38	65	66	43	53.5	54
10	....	68.5	....	40	65	66	47	54	54
11	5 00	68	....	43	65	65.5	49	53.5	53
12	12	67.5	....	46½	64.5	65	52½	53.5	53
13	....	67	....	48½	64.5	65	55½	53	52.5
14	....	65	....	50½	64	64.5	58	52.5	52.5
15	5 23	64	....	53½	64	64	7 01½	53	52
16	....	64	....	55	63	64	05	51.5	51.5
17	....	64	....	58½	63.5	64	08½	51.5	52
18	5 38	64	....	5 00½	63.5	64	11	51.5	52
19	....	63.5	....	02½	64	64	13	51	51.5
20	5 53	[illegible]	....	04½	63.5	64	17	51	52
21	6 15	54	....	06½	63.5	64	19½	51.5	52
22	....	54	....	08	63	63.5	22½	52.5	52.5
23	6 22	55	....	10	63	63.5	26	51.5	54
24	....	52	....	12	63	63.5	30	51	52
25	....	51	....	14	63	63.5	33	50.5	51
26	6 30	51	....	16½	63	63.5	35	51	50.5
27	35	51	....	18	63.5	63	38	51	50
28	....	52	....	20	63	63.5	40½	49.5	50
29	....	52.5	....	22	63	64	44	49.5	51
30	6 43	57	....	24	63.5	63.5	46	51	53
31	....	58	....	27	63	63	48½	53.5	54
32	6 50	59	....	5 29	63	63	7 51½	54	54
Mean............		62.42			63.98	64.55		52.27	52.41
Approx. corr...		−1.42	....		−1.20			−1.05	
Corr. mean.....		61			62.78			51.22	

NOTE.—G is a compared thermometer of the Mississippi River Commission, and H an uncompared thermometer graduated only to 2° intervals.

The 26th was calm and smoky and not excessively warm. The first measurement was made in connection with other work and during a great range of temperature. The second measurement was made on a densely smoky day and begun after a thermometer "in sun" read the same as "in shade," and was completed by daylight without, at any time, any very strong wind. The wind blew strong, however, while the party was passing back over the line preparatory to the third measurement, and the temperature fell ten degrees.

The third measurement was wholly by lamp-light and the wind was almost a calm.

Correction for inclination of tape on Trover's Point Base.

[Sin $i = \frac{h}{l}$; ver sin $i \times l$ = correction; i = angle of inclination; h = difference of elevation; l = length of tape.]

No. of stake.	Elevation.	Difference of elevation.	Log h.	Log sin i.	i.	Log ver sin i.	Log correction.	Correction.
	′	′			° ′			′
▲ E. B.	0.0	....	....	....	......	....	....	....
Zinc E. B.	1.3	....	....	....	......	....	....	....
1	1.3	0.0	....	....	......	....	....	....
2	1.4	0.1	9.00000	6.52418	0 01	....	....	....
3	2.0	0.6	9.77815	7.30233	07	4.81062	6.79244	0.0006
4	2.2	0.2	9.30103	6.82521	02	3.22848	5.70420	0.0001
5	4.2	2.0	0.30103	7.82521	23	5.34988	7.82570	0.0067
6	5.3	1.1	0.04139	7.56557	13	4.85431	7.33013	0.0021
7	6.3	1.0	0.00000	7.52418	12	4.78478	7.26060	0.0018
8	8.6	2.3	0.36173	7.88501	26	5.45637	7.93219	0.0086
9	11.6	3.0	0.47712	8.00130	34	5.68938	8.16520	0.0146
10	10.2	1.4	0.14613	7.67031	16	5.03466	7.51048	0.0032
11	9.6	0.6	9.77815	7.30233	07	4.31062	6.79244	0.0006
12	8.3	1.3	0.11394	7.63812	14	4.91868	7.39450	0.0025
13	7.4	0.9	9.95424	7.47812	10	4.62642	7.10224	0.0013
14	6.7	0.7	9.84510	7.36928	08	4.43260	6.90842	0.0008
15	7.0	0.3	9.47712	7.00130	03	3.58066	6.05648	0.0001
16	7.3	0.3	9.47712	7.00130	03	3.58066	6.05648	0.0001
17	8.1	0.8	9.90309	7.42727	09	4.53491	7.01073	0.0010
18	8.6	0.5	9.69897	7.22315	06	4.18272	6.65854	0.0005
19	10.3	1.7	0.23045	7.75463	20	5.22848	7.70430	0.0051
20	12.3	2.0	0.30103	7.82521	23	5.34988	7.82570	0.0067
21	17.5	5.2	0.71600	8.24018	1 00	6.18271	8.65853	0.0456
22	17.5	0.0	....	....	......	....	....	....
23	16.4	1.1	0.04139	7.56557	12	4.78478	7.26060	0.0018
24	13.9	2.5	0.39794	7.92213	29	5.55121	8.02703	0.0106
25	12.0	1.9	0.27875	7.80293	22	5.31127	7.78709	0.0061
26	11.0	1.0	0.00000	7.52418	12	4.78478	7.26060	0.0018
27	10.5	0.5	9.69897	7.22315	06	4.18272	6.65854	0.0005
28	9.8	0.7	9.84510	7.36928	08	4.43260	6.90842	0.0008
29	12.0	2.2	0.34242	7.86660	25	5.42230	7.89812	0.0079
30	16.5	4.5	0.65321	8.17739	52	6.05842	8.53424	0.0342
31	18.4	1.9	0.27875	7.80293	22	5.31127	7.78709	0.0061
32	22.8	4.4	0.64345	8.16763	51	6.04156	8.51738	0.0329
▲ W. B.	27.4	4.6	0.66276	*8.18694	53	6.07496	8.55078	0.0356
								−0.2403

* Part of tape = 140 feet.

Measurement of the differences at end of each tape, Trover's Point Base Line.

[The first measurement is taken as a standard, and the differences, as recorded, are taken as corrections to the second and third measurements.]

No. of tapes.	First measurement—second measurement.			First measurement—third measurement.		
	Reading on zinc.	Correction.*	Reduced.	Reading on zinc.	Correction.*	Reduced.
	"	"	"	"	"	"
1	+0.160	....	+0.160	+0.415	....	+0.415
2	+0.225	....	+0.225	+0.720	....	+0.720
3	+0.335	....	+0.335	+1.090	....	+1.090
4	+0.455	....	+0.455	+1.490	....	+1.490
5	+0.550	....	+0.550	+1.885	....	+1.885
6	+0.645	....	+0.645	+2.230	....	+2.230
7	+0.725	....	+0.725	+2.505	....	+2.505
8	+0.775	....	+0.775	+2.920	....	+2.920
9	+0.835	....	+0.835	+3.270	....	+3.270
10	+0.885	....	+0.885	+3.600	....	+3.600
11	+0.960	....	+0.960	+3.940	....	+3.940
12	+0.985	....	+0.985	+4.245	....	+4.245
13	+1.030	....	+1.030	+4.575	....	+4.575
14	+1.030	....	+1.030	+4.825	....	+4.825
15	+1.040	....	+1.040	+5.090	....	+5.090
16	+1.045	....	+1.045	+5.410	....	+5.410
17	+1.085	....	+1.085	+5.700	....	+5.700
18	+1.115	....	+1.115	+6.000	....	+6.000
19	+1.060	....	+1.060	+6.255	....	+6.255
20	+1.045	....	+1.045	+6.515	....	+6.515
21	+0.835	....	+0.835	+6.690	....	+6.690
22	+0.605	....	+0.605	+6.735	....	+6.735
23	+0.385	....	+0.385	+6.840	....	+6.840
24	+0.110	....	+0.110	+6.890	....	+6.890
25	−0.160	....	−0.160	+6.920	....	+6.920
26	−0.465	....	−0.465	+6.925	....	+6.925
27	−0.700	....	−0.700	+7.005	....	+7.005
28	−0.915	....	−0.915	+7.115	....	+7.115
29	−1.120	....	−1.120	+7.225	....	+7.225
30	−1.280	....	−1.280	+7.305	....	+7.305
31	−1.390	....	−1.390	+7.430	....	+7.430
32	−1.445	....	−1.445	+7.535	....	+7.535

* No correction.

COMPARISON OF STANDARD TAPE WITH 299 FEET OF THE 500-FOOT TAPE.

[Done in connection with the Benton and Trover's Point Base Line measurements.]

The portion of the broken 500-foot tape used bears graduation marks every ten feet from 0 to 430′, and there is one splice in it. A mark is *filed* in the tape to represent 299′ of the standard tape as graduated. A mark is also *cut* in the solder on the first portion of the imperfectly marked 300-foot graduation at just one foot, by boxwood scale, from the filed mark.

Clamps were made fast to the tape near the zero and the 300-foot graduations; then the same apparatus, weight, and method as used in base-line measurements was alternately applied in stretching the tape. The standard tape was first stretched and a mark made on the zinc at the 299-foot graduation, which mark was the standard of comparison.

On July 10, at the Benton base, seven comparisons were made, giving a mean result for length from zero to *filed* mark on 500-foot tape=0″.035=0′.003 longer than the standard tape, or =299′.082 under a 16-pounds tension at 62° Fahr. (Mean temperature at the time of comparison was 80° Fahr.) An identical result from five comparisons at Trover's Point base on September 28 was obtained; mean temperature at the time of comparison was 66° Fahr.

The adopted length of the 500-foot tape from the zero graduation to the cut in the solder at the 300-foot graduation is =300′.082 at 62° Fahr. under 16 pounds tension.

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

APPENDIX A 3*f*.

OLNEY BASE.

Determination of one tape-length at 62° Fahr.

The first measurement at the mean temperature of the tape at the time of measurement may be expressed as follows:

$$36 \text{ tapes} + \frac{1 \text{ tape} + 1 \text{ foot}}{6} + 1'.500 - 0'.127 + 4'.327 - 0'.133 = 10821'.9662$$

where:

First term is number of entire tape lengths (between 0 and 299 foot graduations).

Second term is distance between second measurement mark on zinc 36ᵃ, which mark is the mean of six successive applications of 50′ portions of tape under a strain of 16 pounds, and for the last 50′ applying one foot of a box-wood scale to the 299-foot graduation to make out the 50′. (The extreme of the six marks on stake 36ᵃ were but 0.02 of an inch apart.)

Third term is amount set ahead = 8″ on stake 17, and 10″ on stake 28.

Fourth term is the total inclination-of-tape correction.

Fifth term is the distance from the mark on 36ᵃ, above noted, to the mark on zinc over △ middle base as measured with a box-wood scale.

Sixth term is the reduction of first measurement mark to second measurement mark, as shown on zinc 36, and the second member is the known distance between △ east base and △ middle base. (See page 303, No. 24, of Professional Papers, Corps of Engineers.)

Transposing the known quantities in the equation to the second member we have: 36⅙ tapes=10816′.232; or one tape, at tape temperature (55°.54 Fahr.)=299′.0663.

The reduction to 62° Fahr., with coefficient of expansion = 0.000007, is = 0′.0136; or one tape at 62° Fahr., under 16 pounds tension = 299′.0799.

The second measurement, at the mean temperature of the tape at the time of measurement, may be expressed as follows:

$$36 \text{ tapes} + \frac{1 \text{ tape} + 1 \text{ foot}}{2} + 1'.498 - 0'.127 + 4'.327 = 10821'.9662$$

where the terms are the same as above described except that the third term is amount set forward = 9″ on stake 12, and 8″.98 on stake 27, and the sixth term is zero.

From this equation we obtain: 36½ tapes = 10816′.101; or one tape, at tape temperature, 53°.83 Fahr., = 299′.0627. The reduction, to 62° Fahr., is = +0.0171; or one tape, at 62° Fahr., under 16 pounds tension = 299′.0798.

The difference in the two measurements is, for 36 tapes, expressed by the difference between the sixth term in the first equation (0′.133) and the product of (10816′ — 50′), (55.54 — 53.83), and 0.000007; or by 0′.133 — 0′.129 = 0.004 of a foot. This difference in the two measurements is one in 2,700,000.

The mean of the two values for one tape is 299′.07985. To this it is necessary to apply a minus correction (of 0′.00085, or about 1 in 350,000), due to the fact that the horizontal lever-arm was inadvertently lengthened by the tenth of an inch (0″.10), in the following manner: Before measuring the Benton base the bail of the weight-can had been made more secure by a smaller wire, and this wire was used in suspending the can. The person carrying and suspending the can, on its hook, at the Olney base, used the larger lower wire, the center of which was crowded out by the block (see drawing) farther than the bearing of the smaller wire by 0″.10, by actual measurement.

The adopted value for one tape length = 299′.079 at 62° Fahr., under 16 pounds tension.

The tape is a standard *as graduated* under a 16-pounds tension at 24½° Fahr., or under a tension of 1¼ pounds at 62° Fahr. [using coefficient of expansion = 0.000007 for 1° Fahr. and extension of tape = 0′.00538 for one pound tension; as given for this same tape from the office of the Mississippi River Commission].

The mean error of the adopted value is not greater than ±0′.0005, or the probable error not greater than ±0′.00034.

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

Temperatures of Olney Base.

Number of tape.	First measurement.			Second measurement.		
	Oct 28, 1885. Time.	Thermometers.		Oct. 28, 1885. Time.	Thermometers.	
		G.	H.		G.	H.
	A. M.	° F.	° F.	P. M.	° F.	° F.
1	10:11	55.0	56.0	2:10	54.5	55.5
2	16	55.	56.	14	54.5	55.
3	21	55.5	56.	17½	54.8	55.
4	26	56.3	56.	23	54.8	54.5
5	31	56.8	56.5	27	54.8	55.
6	35	57.0	56.5	32	54.5	54.5
7	40	57.0	57.	38	54.3	54.5
8	44	57.0	57.	42	54.0	54.5
9	48	57.2	57.	46	54.1	54.5
10	52	57.	57.5	50	54.1	54.5
11	55½	57.5	58.	53	54.3	55.
12	59½	57.7	57.5	56½	54.5	55.
13	11:02½	57.2	57.5	3:05	54.6	55.5
14	06	58.	58.	08	54.9	56.
15	10	56.	57.	11	55.	55.5
16	13	56.	57.	16	55.	55.5
17	16	57.	57.5	19	55.1	55.5
18	25	57.	57.	23½	55.	55.5
19	29	56.7	56.5	27½	55.	56.
20	33	56.7	57.	31	55.1	56.
21	37	57.	56.	34½	55.3	56.
22	40	56.7	57.	38	55.4	56.
23	45	56.5	56.5	43	55.4	56.
24	50	56.	56.	47	55.6	56.
25	53½	56.5	56.5	52	55.5	56.
26	57½	56.5	56.5	56	55.5	56.
	P. M.					
27	12:01	56.4	56.5	4:00	55.5	56.
28	04½	56.8	56.5	09	55.5	56.
29	09	55.8	56.5	13	55.5	56.
30	16½	56.3	57.	18	55.6	56.
31	21½	56.1	57.	23	55.5	56.
32	25½	56.3	57.	27	55.2	56.
33	33	57.1	57.5	31	55.1	56.
34	36	57.9	57.5	35	55.0	55.5
35	40	58.	58.	39	55.0	55.5
36	46	57.5	58.	42	55.	55.5
36*	....	....	....	4:50 to 5:03	55.	55.4
	....	61.0	60.0		35.5	17.9
Mean		56.69	56.92		54.96	55.48
Correction ..		−1.15	....		−1.13	....
Correct mean		55.54	....		53.83	....

First measurement—second measurement = 55°.54 — 53°.83 = 1°.71 F.

NOTE.—The morning was completely overcast after a rainy night. Wind easterly but slight. Misting quite hard at beginning of second measurement. The atmosphere was about at complete saturation.

G thermometer is a compared one of the Mississippi River Commission.
H thermometer is a private one of Mr. Humphreys, and uncompared.

Correction for inclination of tape on Olney Base.

[$\sin i = \frac{h}{l}$; correction = ver sin $i \times l$; i = angle on inclination; h = difference of elevation; l = length of tape.]

No. of stake.	Elevation.	h	Log h.	Log sin i.	i	Log ver sin i.	Log correction.	Correction.
	'	'			° ' "			'
△ E. B.	107.78	.....	....	....	....	....	....	....
Zinc △ E. B. ...	112.28	.....	....	....	....	....	....	....
1	106.48	5.80	0.76343	8.28765	1 06 40	6.27423	8.75001	0.0562
2	103.52	2.96	0.47129	7.99551	34 00	5.68988	8.16516	0.0146
3	102.94	0.58	9.76343	7.28765	6 40	4.27424	6.75002	0.0006
4	103.17	0.23	9.36173	6.88595	2 40	3.47836	5.95414	0.0001
5	104.01	0.84	9.92428	7.44850	9 40	4.59098	7.07276	0.0012
6	104.20	0.19	9.27875	6.80297	2 10	3.29800	5.77378	0.0001
7	103.88	0.32	9.50515	7.02937	3 40	3.75496	6.23074	0.0002
8	103.44	0.44	9.64345	7.16767	5 00	4.02436	6.50014	0.0003
9	103.80	0.36	9.55630	7.08052	4 10	3.86600	6.34178	0.0002
10	103.64	0.16	9.20412	6.72834	1 50	3.15290	5.62968	0.0000
11	103.01	0.63	9.79934	7.32356	7 15	4.34710	6.82288	0.0007
12	102.90	0.11	....	....	....	....	....	0.0000
13	103.16	0.26	9.41497	6.93919	3 00	3.58066	6.05644	0.0001
14	102.02	1.14	0.05690	7.58112	13 10	4.86538	7.34116	0.0022
15	103.38	1.36	0.13354	7.65776	15 40	5.01638	7.49216	0.0031
16	103.95	0.57	9.75587	7.28009	6 30	4.25225	6.72803	0.0005
17	103.94	0.01	....	....	....	....	....	....
18	103.63	0.31	9.49136	7.01558	3 30	3.71456	6.19034	0.0002
19	103.37	0.26	....	....	....	....	....	0.0001
20	103.45	0.08	....	....	....	....	....	0.0000
21	103.57	0.12	....	....	....	....	....	0.0000
22	103.16	0.41	9.61278	7.13700	4 40	3.96444	6.44022	0.0003
23	103.01	0.15	....	....	....	....	....	0.0000
24	102.84	0.17	9.23045	6.75467	1 55	....	....	0.0000
25	102.43	0.41	....	....	....	....	....	0.0003
26	102.41	0.02	....	....	....	....	....	0.0000
27	102.25	0.16	....	....	....	....	....	0.0000
28	101.61	0.64	9.80618	7.33040	7 20	4.35702	6.83280	0.0007
29	104.05	2.44	0.38739	7.91161	28 00	5.52074	7.99652	0.0099
30	106.85	2.80	0.44716	7.97138	32 10	5.64124	8.11702	0.0131
31	103.45	3.40	0.53148	8.05570	39 05	5.81041	8.28619	0.0193
32	104.26	0.81	9.90849	7.43271	9 20	4.56650	7.04228	0.0011
33	104.12	0.14	....	....	....	....	....	0.0000
34	104.13	0.01	....	....	....	....	....	0.0000
35	103.44	0.69	9.83885	7.36307	7 55	4.42351	6.89929	0.0008
36	104.16	0.72	9.85733	7.38155	8 20	4.46806	6.94384	0.0009
(50') 36a	103.90	0.26	9.41497	7.71600	17 53	5.18132	6.88029	0.0007
Zinc △ M. B. ..	103.88	0.02	....	....	....	....	....	....
△ Mid. base ..	100.00 = (assumed elevation.)						Total......	0.1275

Measurement of the differences at end of each tape, Olney Base.

No. of tape.	Second measurement—first measurement.			Remarks.
	Reading on zinc.	Correction.	Reduced.	
	"		"	
1	+ 0.02	....	+ 0.02	The last column contains accumulative differences in the two measurements, due to incidental errors and to expansion in tape, for which, if a difference of temperature correction be taken, it is then possible to compute a probable error for one tape measurement.
2	+ 0.04	....	+ 0.04	
3	+ 0.05	....	+ 0.05	
4	+ 0.06	....	+ 0.06	
5	+ 0.03	....	+ 0.03	
6	+ 0.01	....	+ 0 01	
7	— 0.14	....	— 0.14	
8	— 0.20	....	- 0.20	
9	— 0.29	....	— 0.29	
10	— 0.39	....	— 0.39	
11	— 0.49	....	— 0.49	
12	— 0.58	....	— 0.58	
13	+ 8.32	+ 9".00	— 0.68	Set ahead on second measurement on zinc [illegible] 9".00.
14	+ 8.22	....	— 0.78	
15	+ 8.15	....	— 0.85	
16	+ 8.08	....	— 0.92	
17	+ 8.00	....	— 1.00	
18	— 0.10	— (8".00 — 9".00)	— 1.10	Set ahead on first measurement on zinc [illegible] 8".00.
19	— 0.13	....	— 1.13	
20	— 0.24	....	— 1.24	
21	— 0.28	....	— 1.28	
22	— 0.32	....	— 1.32	
23	— 0.34	....	— 1.34	
24	— 0.27	....	— 1.27	
25	— 0.28	....	— 1.28	
26	— 0.31	....	— 1.31	
27	— 0.31	....	— 1.31	
28	+ 8.65	— (— 8".98 + 8".00 — 9".)	— 1.33	Set ahead on second measurement, on zinc [illegible] 8".98.
29	— 1.31	— (10".— 8".98 + 8" — 9".)	— 1.27	Set ahead on first measurement, on zinc [illegible] 10".00.
30	— 1.32	....	— 1.30	
31	— 1.35	....	— 1.33	The second measurement is taken as a standard, and the differences recorded as corrections to the first measurement.
32	— 1.34	....	— 1.32	
33	— 1.43	....	— 1.41	
34	— 1.51	....	— 1.49	
35	— 1.55	....	— 1.53	
36	— 1.61	....	— 1.59	

APPENDIX A 3*g*.

OFFICE OF THE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., February 11, 1886.

DEAR SIR: I find in Mr. Wisner's note-books the following values of divisions of levels:

T. & S. No. 1. Tube No. 2. First Division=1".70.
T. & S. No. 1. Striding Level. First Division=1".171.
T. & S. No. 2. Striding Level. First Division=1".24.

Very respectfully, yours,

L. L. WHEELER.

Mr. O. B. WHEELER,
U. S. Assistant Engineer

VALUE OF STRIDING LEVEL, T. & S. THEODOLITE, NO. 1.

The following readings were taken, at the Benton Base, for the value of one division f the striding level used in azimuth work at the Benton and Trover's Point Bases; he level was placed on the telescope tube of the theodolite, and a common leveling od set up at a distance of two tape lengths (or 598′.16):

	Level.		Rod.	
	E.	W.		
	34 divisions.	34 divisions.	′ 3.844	(Not used in computing.)
(1)	20.0 50.4	50.0 20.0	3.755 3.9275	1 div. = $\frac{.1725}{30.2 \times 598.16}$ = 1″.975
Mean	30.4 30.2	30.0	.1725	
(2)	50.3 22.	20.5 49.8	3.919 3.7455	1 div. = $\frac{.1735}{28.8 \times 598.16}$ = 2″.068
Mean	28.3 28.8	29.3	.1735	
(3)	19.2 47.8	53.0 24.5	3.737 3.899	1 div. = $\frac{.162}{28.55 \times 598.16}$ = 1″.960
Mean	28.6 28.55	28.5	.162	Mean value 1 division = 2″.000

Respectfully submitted.

O. B. WHEELER,
Assistant Engineer

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A., Secretary Missouri River Commission.

APPENDIX A 3*h*.

Table showing approximate slope of river from Fort Benton to Trover's Point, derived from levels taken between July 20, 1885, and September 30, 1885.

[Corrected by readings on Fort Benton gauge.]

Date.	Number of B. M.	Water surface.				Distance between B. M.	Slope per mile between B. M.	Total fall from Fort Benton.
		Recorded elevation.	Change in gauge.	Corrected for gauge reading.	Fall between B. M.			
1885.		*Feet*	*Feet.*	*Feet.*	*Feet.*	*Miles.*	*Feet.*	*Feet.*
July 20	"Powers," W. G. B. M	2,69[illegible]	0.00	2,690.33	00.00	0.88	0.00	00.00
22	[illegible]	2,6[illegible]	—0.40	2,657.38	32.95	7.80	4.22	32.95
23	[illegible]	2,046.25	—0.60	2,646.85	10.53	3.42	3.08	43.48
23	[illegible]	2,636.88	—0.60	2,637.48	9.37	3.00	3.12	52.85
24	[illegible]	2,6[illegible]8.16	—0.70	2,628.86	8.62	2.40	3.59	61.47
25	Mouth of Marias	2,622.00	—0.[illegible]0	2,622.[illegible]0	6.06	1.56	3.88	67.53
27	[illegible]	2,621.02	—1.00	2,622.02	0.78	0.46	1.70	68.31
27	[illegible]	2,613.07	—1.00	2,614.97	7.05	2.47	2.85	75.36
27	[illegible]	2,6[illegible]0.39	—1.00	2,611.39	3.58	1.53	2.34	78.94
28	[illegible]	2,606.12	—1.00	2,607.12	4.27	1.44	2.96	83.21
28	[illegible]	2,601.30	—1.00	2,602.30	4.82	1.67	2.88	88.03
28	Boat Creek	2,598.85	—1.00	2,599.85	2.45	1.03	2.38	90.48

Table showing approximate slope of river from Fort Benton to Trover's Point, &c.—Cont'd.

Date.	Number of B. M.	Water surface.				Distance between B. M.	Slope per mile between B. M.	Total fall from Fort Benton.
		Recorded elevation.	Change in gauge.	Corrected for gauge reading.	Fall between B. M.			
1885.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*	*Feet.*	*Feet.*
July 29	....	2,593.89	−1.00	2,594.89	5.46	1.86	2.93	95.94
29	....	2,589.07	−1.00	2,590.07	4.32	2.11	2.05	100.2[illegible]
30	Hd. Bend above Coal Bank.	2,584.20	−1.00	2,585.20	4.87	2.07	2.35	105.1[illegible]
30	....	2,580.62	−1.00	2,581.62	3.58	2.35	1.52	108.71
31	....	2,573.92	−1.00	2,571.92	6.70	4.47	1.50	115.41
31	....	2,570.59	−1.00	2,571.59	3.33	3.81	0.87	118.74
Aug. 1	....	2,562.70	−1.00	2,563.70	7.89	4.19	1.88	126.6[illegible]
3	....	2,557.94	−1.20	2,559.14	4.56	5.01	0.91	131.1[illegible]
3	....	2,553.05	−1.20	2,554.25	4.80	2.69	1.83	136.[illegible]
4	....	2,549.37	−1.30	2,550.67	3.58	1.96	1.82	139.[illegible]
4	....	2,542.23	−1.30	2,543.53	7.14	2.70	2.65	146.[illegible]
5	....	2,538.58	−1.40	2,539.98	3.55	2.39	1.49	150.[illegible]
5	Hole in Wall..............	2,537.50	−1.40	2,535.90	1.08	0.43	2.51	151.4[illegible]
5	....	2,529.96	−1.40	2,531.36	7.54	3.58	2.11	158.[illegible]
6	....	2,524.22	−1.50	2,525.72	5.64	3.64	1.55	164.[illegible]
7	Ring bolt.................	2,518.23	−1.55	2,519.78	5.94	3.68	1.61	170.[illegible]
8	....	2,508.26	−1.60	2,509.86	9.92	4.01	2.47	180.[illegible]
8	....	2,498.01	−1.60	2,499.61	10.25	4.36	2.35	190.7[illegible]
10	....	2,490.95	−1.70	2,492.65	6.96	2.64	2.63	197.[illegible]
11	....	2,483.61	−1.75	2,485.36	7.29	3.67	1.98	204.[illegible]
11	....	2,479.40	−1.75	2,481.15	4.21	3.64	1.16	209.[illegible]
12	....	2,468.49	−1.80	2,470.29	10.86	3.53	3.08	220.[illegible]
12	....	2,461.46	−1.80	2,463.26	7.03	2.05	3.43	227.[illegible]
13	....	2,457.06	−1.85	2,458.91	4.35	2.41	1.80	231.[illegible]
15	+1882, bench-mark	2,448.79	−2.10	2,450.89	8.02	2.69	3.00	239.4[illegible]
15	....	2,439.60	−2.10	2,441.70	9.19	3.31	2.78	248.[illegible]
17	....	2,427.29	−2.15	2,429.44	12.26	3.55	3.45	260.[illegible]
17	....	2,414.47	−2.15	2,416.62	12.82	4.28	3.00	273.[illegible]
18	....	2,403.54	−2.20	2,405.74	10.88	4.29	2.54	284.[illegible]
21	....	2,394.71	−2.30	2,397.01	8.73	3.10	2.82	293.[illegible]
22	....	2,386.90	−2.30	2,389.20	7.81	4.37	1.79	301.[illegible]
22	....	2,378.99	−2.30	2,381.29	7.91	3.03	2.61	309.[illegible]
24	....	2,374.76	−2.00	2,376.76	4.53	2.82	1.61	313.[illegible]
24	....	2,366.27	−2.00	2,368.27	8.49	4.48	1.90	322.[illegible]
24	....	2,357.21	−2.00	2,359.21	9.06	3.11	2.91	331.[illegible]
25	....	2,347.94	−1.90	2,349.81	9.37	4.65	2.02	340.4[illegible]
26	....	2,342.94	−1.92	2,344.86	4.98	3.85	1.32	345.4[illegible]
26	....	2,340.12	−1.92	2,342.04	2.82	2.23	1.26	348.2[illegible]
26	....	2,336.00	−1.92	2,337.92	4.12	2.62	1.57	352.4[illegible]
27	....	2,330.30	−1.80	2,332.10	5.83	2.54	2.29	358.[illegible]
27	....	2,327.29	−1.80	2,329.09	3.01	2.58	1.17	361.[illegible]
28	....	2,325.42	−1.65	2,327.07	2.02	2.35	0.86	363.[illegible]
29	....	2,319.71	−1.60	2,321.31	5.76	4.04	1.42	368.[illegible]
29	....	2,313.66	−1.60	2,315.26	6.05	4.46	1.36	373.9[illegible]
29	....	2,310.82	−1.60	2,312.42	2.84	3.86	0.74	377.[illegible]
Sept. 2	....	2,302.90	−1.80	2,304.70	7.72	4.16	1.13	385.[illegible]
2	....	2,299.89	−1.80	2,301.69	3.01	2.22	1.36	388.[illegible]
2	....	2,294.28	−1.80	2,296.08	5.61	2.75	2.04	394.[illegible]
3	....	2,291.19	−1.85	2,293.04	3.04	2.62	1.16	397.[illegible]
3	....	2,287.43	−1.85	2,289.28	3.76	3.35	1.12	401.05
4	....	2,282.56	−1.90	2,284.46	4.82	2.48	1.94	405.87
5	....	2,278.71	−1.90	2,280.61	3.85	2.56	1.50	409.7[illegible]
7	....	2,268.29	−1.95	2,270.24	10.37	7.55	1.37	420.[illegible]
8	....	2,264.06	−2.00	2,266.06	4.18	4.13	1.01	424.2[illegible]
8	....	2,258.44	−2.00	2,260.44	5.62	3.77	1.49	42[illegible]
8	....	2,254.92	−2.00	2,256.92	3.52	2.77	1.27	433.[illegible]
9	....	2,250.77	−2.00	2,252.77	4.15	2.48	1.67	437.[illegible]
9	....	2,245.95	−2.00	2,247.95	4.82	3.04	1.59	442.[illegible]
11	....	2,243.55	−2.10	2,245.65	2.30	3.09	0.74	444.[illegible]
11	....	2,239.56	−2.15	2,241.71	3.94	2.65	1.49	448.[illegible]
11	....	2,234.22	−2.15	2,236.37	5.34	3.51	1.52	453.[illegible]
12	....	2,230.71	−2.20	2,232.91	3.46	3.33	1.04	457.[illegible]
12	....	2,225.65	−2.20	2,227.85	5.06	3.33	1.52	462.[illegible]

APPENDIX A 3*i*.

***Table showing elevations of permanent bench-marks and corrected elevations of water surfaces, as derived from levels run between Fort Benton and Trover's Point, Montana, during the season of* 1885.**

Permanent bench-marks.	Distance from Fort Benton.	Elevations.					Difference in elevation between bench-marks.
		First determination.	Check.	Difference, first over check.	Adopted.	Water surface.	
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
P. B. M.	0.00	2,700.00	2,700.00	0.000	2,700.000	....	....
U. S. S. S., mercury in barometer	0.17	2,708.308	2,708.299	+0.004	2,708.301	....	+ 8.302
Powers, July 20, W. G. bench-mark	0.38	2,704.560	2,704.573	—0.013	2,704.560	2,690.33	— 3.741
P. B. M.	0.57	2,704.001	2,704.008	—0.007	2,704.001	....	— 0.559
P. B. M.	2.00	2,693.232	2,693.232	0.000	2,693.232	....	—10.709
P. B. M.	4.18	2,681.793	2,681.789	+0.004	2,681.793	....	—11.439
P. B. M.	6.82	2,679.801	2,679.832	—0.031	2,679.816	....	— 1.977
P. B. M.	8.18	2,668.002	2,668.007	—0.005	2,668.002	2,657.38	—11.814
P. B. M.	11.60	2,659.821	2,659.807	+0.014	2,659.821	2,646.85	— 8.181
P. B. M.	12.00	2,657.884	2,657.873	+0.011	2,657.884	....	— 1.937
P. B. M.	14.60	2,653.312	2,653.299	+0.013	2,653.312	2,637.48	— 4.572
P. B. M.	17.00	2,639.177	2,639.182	—0.005	2,639.177	2,628.86	—14.135
P. B. M.	17.83	2,644.635	2,644.658	—0.023	2,644.647	....	+ 5.470
Opposite mouth of Marias River	18.56	....	....	....	....	2,622.80	....
P. B. M.	19.00	2,636.962	2,636.966	—0.004	2,636,962	2,622.02	— 7.685
P. B. M.	21.47	2,633.131	....	....	....	2,614.97	— 3.831
P. B. M.	23.00	2,628.826	....	....	....	2,611.89	— 4 305
P. B. M.	24.44	2,623.767	....	....	....	2,607.12	— 5.059
P. B. M.	26.11	2,615.749	....	....	....	2,602.30	— 8.018
Opposite Goat Creek	27.14	....	....	....	....	2,599.85	....
P. B. M.	27.55	2,624.557	2,624.570	—0.013	2,624.563	....	+ 8.814
P. B. M.	29.00	2,605.554	....	....	....	2,594.89	—10.009
P. B. M.	29.26	2,610.510	....	....	....	....	+ 4.956
P. B. M.	31.11	2,606.862	....	....	....	2,590.07	— 3.648
Head of bend above coal bank	33.18	....	....	....	....	2,585.20	....
At coal banks, bench-mark	35.53	2,601.905	....	....	....	2,581.62	— 4.957
P. B. M.	36.33	2,603.649	....	....	....	....	+ 1.744
P. B. M.	40.00	2,588.050	....	....	....	2,574.92	—15.599
P. B. M.	40.46	2,595.017	....	....	....	....	+ 6.967
P. B. M.	43.51	2,580.882	....	....	....	2,571.59	—14.135
P. B. M.	48.00	2,595.681	....	....	....	2,563.70	+14.799
P. B. M.	53.01	2,573.209	....	....	....	2,559.14	—22.472
P. B. M.	55.70	2,581.478	....	....	....	2,554.25	+ 8.269
P. B. M.	57.68	2,567.619	....	....	....	2,550.67	—13.859
P. B. M.	58.13	2,579.728	....	....	....	....	+12.109
P. B. M.	60.88	2,565.682	....	....	....	2,543.53	—14.046
P. B. M.	62.77	2,560.571	....	....	....	2,539.98	— 5.111
At the base of wall at Hole in Wall	63.20	....	....	....	....	2,538.90	....
P. B. M.	66.78	2,542.301	....	....	....	2,531.36	—18.270
P. B. M.	70.42	2,541.724	....	....	....	2,525.72	— 0.577
Bench-mark at head of Pablos Rapids, Ring bolt	74.10	2,521.850	2,521.862	—0.012	2,521.856	2,510.78	—19.868
P. B. M.	74.29	2,533.002	2,533.023	—0.021	2,533.012	....	+11.156
P. B. M.	78.11	2,532.927	....	....	....	2,509.86	— 0.085
P. B. M.	78.48	2,521.225	....	....	....	....	—11.702
P. B. M.	82.47	2,514.617	....	....	....	2,499.61	— 6.608
P. B. M.	85.11	2,507.060	....	....	....	2,492.65	— 7.557
P. B. M.	88.78	2,523.905	....	....	....	2,485.36	+15.845
Opposite mouth of Judith River, bench-mark	92.42	2,489.941	....	....	....	2,481.15	—33.964
P. B. M.	95.95	2,502.074	....	....	....	2,470.20	+12.133
P. B. M.	98.00	2,472.530	....	....	....	2,463.26	—29.544
P. B. M.	100.41	2,481.401	2,481.424	—0.023	2,481.411	2,458.91	+ 8.881
P. B. M.	103.00	2,481.497	2,481.521	—0.024	2,481.507	....	+ 0.096
+ on stone 500′ below house at Gallatin, foot of Gallatin Rapids, + 1883	108.10	2,456.417	....	....	....	2,450.80	—25.090
P. B. M.	109.41	2,468.725	....	....	....	2,441.70	+12.308
Foot of Dauphine Rapids, bench-mark	109.98	2,445.738	....	....	....	2,429.44	—22.987

Table showing elevations of permanent bench-marks, &c.—Continued.

Permanent bench-marks.	Distance from Fort Benton.	Elevations.					Difference in elevation between bench-marks.
		First determination.	Check.	Difference, first over check.	Adopted.	Water surface.	
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Head of Chimney Bend, bench-mark, Ψ	114.24	2,440.146	....	....	....	2,416.62	+ [illegible]
Head of Picot Rapids, bench-mark, Ψ	118.53	2,421.556	....	....	....	2,405.74	−24.[illegible]
Head of Bird's Rapids, bench-mark, Ψ	121.63	2,429.705	....	....	....	2,397.01	+2.[illegible]
P. B. M., Ψ	126.00	2,406.939	2,406.955	−0.016	2,406.939	2,389.29	−22.[illegible]
Foot of Second Sturgeon Island, bench-mark, Ψ	129.03	2,416.313	....	....	....	2,381.29	+ [illegible]
P. B. M., Ψ	131.85	2,395.520	....	....	....	2,376.76	−2[illegible]
Head of Cow Island, bench-mark, Ψ	136.83	2,380.845	....	....	....	2,368.27	−14.[illegible]
Below Cow Island, bench-mark, Ψ	139.44	2,387.033	....	....	....	2,359.21	+ [illegible]
Head of Dexter Chute, bench-mark, Ψ	144.09	2,391.438	....	....	....	2,349.84	+ [illegible]
P. B. M., Ψ	147.94	2,369.839	....	....	....	2,344.86	−21.[illegible]
Head of Grand Island, bench-mark, Ψ	150.17	2,380.464	....	....	....	2,342.04	+1[illegible]
P. B. M., Ψ	152.79	2,367.020	....	....	....	2,337.92	−[illegible]
P. B. M., Ψ	155.33	2,346.894	....	....	....	2,332.10	−[illegible]
P. B. M., Ψ	157.91	2,348.817	....	....	....	2,329.09	+1.[illegible]
Opposite Armul Creek, bench-mark, Ψ	160.26	2,355.030	....	....	....	2,327.07	+ [illegible]
Head of Harriet Island, bench-mark, Ψ	164.30	2,350.881	....	....	....	2,321.31	− [illegible]
Warm Spring Creek, bench-mark, Ψ	168.76	2,341.203	....	....	....	2,315.26	− [illegible]
Head of Rocky Point Bend, bench-mark, Ψ	172.62	2,327.694	2,327.729	−0.035	2,327.694	2,312.48	−[illegible]
P. B. M., Ψ	176.78	2,348.592	2,348.621	−0.029	2,348.606	2,304.70	+[illegible]
P. B. M., Ψ	179.00	2,322.967	....	....	....	2,301.09	−[illegible]
P. B. M., Ψ	181.75	2,330.799	....	....	....	2,296.08	+7.[illegible]
Foot of Ryan's Island, bench-mark, Ψ	184.37	2,331.280	....	....	....	2,293.04	+ [illegible]
P. B. M., Ψ	187.72	2,322.657	....	....	....	2,289.28	− [illegible]
P. B. M., Ψ	190.20	2,306.379	....	....	....	2,284.46	−16.[illegible]
Foot of island, in Hawley Bend, bench-mark, Ψ	192.76	2,314.847	....	....	....	2,280.61	+8.[illegible]
P. B. M., Ψ	196.71	2,289.641	2,280.627	+0.017	2,289.644		−25.[illegible]
P. B. M., Ψ	200.31	2,290.917	....	....	....	2,270.24	+1.[illegible]
P. B. M., Ψ	204.46	2,286.712	....	....	....	2,266.06	−4.[illegible]
P. B. M., Ψ	208.23	2,284.269	....	....	....	2,260.44	−2.[illegible]
Head of Muscle Shell Island, bench-mark, Ψ	211.00	2,274.381	....	....	....	2,256.92	−1.[illegible]
Head of Muscle Shell Rapids, bench-mark, Ψ	213.48	2,291.004	....	....	....	2,252.77	+16.[illegible]
P. B. M., Ψ	216.52	2,271.351	2,271.298	+0.053	2,271.351	2,247.95	−19.[illegible]
P. B. M., Ψ	219.61	2,285.453	2,285.476	−0.023	2,285.460	2,245.65	+14.[illegible]
P. B. M., Ψ	222.26	2,271.607	2,271.585	+0.022	2,271.607	2,241.71	−1[illegible]
P. B. M., Ψ	225.77	2,258.637	2,258.685	−0.048	2,258.637	2,236.37	−12.[illegible]
Head of Elk Island, bench-mark, Ψ	229.10	2,245.112	2,245.145	−0.033	2,245.112	2,232.91	−13.[illegible]
Opposite Forgey's wood-yard, bench-mark, Ψ	232.43	2,255.533	2,255.549	−0.016	2,255.549	2,227.85	+10.[illegible]
P. B. M., Ψ	232.73	2,245.189	2,245.199	−0.010	2,245.189	....	−10.[illegible]
P. B. M., Ψ to "Y" } P. B. M., Ψ to "Y" }	232.88 233.71	} 2,245.442	2,245.452	−0.010	2,245.452	....	+ [illegible]

APPENDIX A 4.

REPORT OF MR. JAMES A. SEDDON, ASSISTANT ENGINEER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., July 1, 1886.

SIR: I have the honor to make the following report of the physical data department for the fiscal year ending June 30, 1886:

COMPILATION OF THE DATA.

Gauges.—Full histories of the reduction of the gauge-readings were compiled for office use; also, histories of the changes of location and zero to go with the yearly sheets of mean daily gauge-readings. The 1885 sheets have also been reduced and compiled for the 17 regular United States Engineer gauges and the Signal Service gauge-station of Hermann, Mo. All these sheets, viz, 215, with their histories, have been stereotyped and an edition is being printed. All the gauges were checked and repaired, October 14 to December 9, 1885, and again May 20 to June 13, 1886.

Cross-section and slope.—The 560 incomplete cross-sections of Lexington, Kansas City, and Leavenworth, mentioned in last Annual Report, have been traced on standard section paper, their areas measured, and tabulations and reference maps made, thus completing the compilation of cross-section data for this division, Vol. III. Seven miles of slope at Kansas City was also plotted and tabulated, completing the slope data for this division.

One hundred and forty-three cross-sections at Omaha were plotted; these, with the the 133 of last Annual Report, are still incomplete, wanting measurement of areas and tabulations.

Discharge.—The compilation of the 168 observations at Saint Charles, 1879, which was mentioned as in progress in last Annual Report, has been completed; also 1 at same point in 1878. This completes the compilations of discharge data for Saint Charles.

The compilation of the Kansas City discharges of 1883, 62 observations in all, was completed. These discharges required replotting to standard scale and the computation and plotting of elements of discharge, measurement of discharge with planimeter, calculation of datum areas, and tabulation. Nineteen discharge observations for Kaw River, at Kansas City, during the same time, were also put in shape. This completes the compilation of discharge data at Kansas City.

Twenty-nine discharge observations at Omaha, in 1882, have been put in shape, with the exception of measurements with planimeter and tabulation.

By reference to the table, as in last Annual Report, showing the condition of the compilation, it will be seen that volumes I, II, III, and IV are about complete with the exception of such miscellaneous data as may be added:

No. of volume.	Local charges at which data were collected.	Cross-sections.	Slope.	Discharged.	Borings.	Miscellaneous.	Remarks.
I	Saint Charles	C	C	C	$\frac{1}{4}$ C	O	
	Cedar City	C	X	X	X	O	
II	Boonville	C	C	X	X	X	No data except low-water survey of 1882.
	Glasgow	C	C	X	X	O	
III	Lexington	C	C	X	X	O	
	Kansas City	C	C	C	X	O	
	Leavenworth	O	C	X	X	O	
IV	Atchison	C	C	C	X	O	Only a few discharges.
	Saint Joseph	C	C	C	X	O	
V	Brownville	O	O	X	X	O	
	Nebraska City	C	C	$\frac{1}{4}$ C	C	O	
	Plattsmouth	O	O	X	C	O	
	Omaha	$\frac{1}{4}$ C	O	$\frac{1}{4}$ C	O	O	
	Sioux City	O	O	O	O	O	
	Vermillion	X	X	X	X	O	Very few data here.

ABBREVIATIONS USED IN TABLE.—C is "Completed," and the degree of completion is given as a fraction of C. O is "No work done on the compilation." X is "Few, if any, data of the kind at the point."

STUDY OF THE DATA.

This has been confined to the plotting and study of gauge relations and the determination of curves of discharge-gauge variation, prior to scaling off discharges at the principal points of the river for each day of the period covered by gauge-readings.

Before stating what has been done in this line it will be necessary to give, in some detail, the reasoning on which the work rests and the steps taken.

It is accepted as an axiom that over a reach of river free from tributaries, say between two points such as Hermann and Saint Charles, if there is a steadily rising river at the upper point, that is, a steadily increasing discharge at Hermann, and the discharge for a given time be taken at Hermann, then *some time* after the same discharge would be found at Saint Charles; of course the same holds for a steadily falling stage and for a stationary river. It is, therefore, concluded that all the discharges that hold at Hermann in the fluctuations of the river will, after a proper interval, hold at Saint Charles, with the following exceptions: short flushes on the low stages, and probably to some degree at the turning points of all rises and falls; also the winter months, when ice action has generally destroyed the sequence of discharg

Without assuming an answer for the Missouri River to the question of how the interval may vary at different stages between the time of the appearance of given discharges at Hermann and their appearance at Saint Charles, or of how much the sequence of discharge may be effected between two points, we may transfer the reasoning from discharge to gauge-heights, giving to the gauge-heights at which the same discharge passes, both Hermann and Saint Charles, the name of "equivalent gauge heights." Bearing in mind that these equivalent gauge-heights mean an actual gauge-reading, which occurs at Hermann when a given discharge holds there, and gauge-reading that will occur at Saint Charles in a short time when the discharge there has changed to the given value; or, in other words, that they simply represent two values, one on the Hermann gauge and one on the Saint Charles gauge, which stand for the same discharge in the discharge-gauge relation existing at Hermann and Saint Charles during that time.

The term, "discharge-gauge relation" is applied to the curve which gives the discharge of the river for all gauge-heights. It is gotten by plotting a series of measured discharges as abscissas to the gauge-heights at which they held, as ordinates, and passing a mean curve through the points so determined. It is known that there are often changes of this curve from year to year, and sometimes between different parts of the same year, as well as an erratic variation of discharge at the higher stages that is not understood.

The first step in the study of gauge data is a determination, from the actual record of the relations connecting equivalent gauge-heights from point to point. The process is as follows, taking the former case of Hermann and Saint Charles: the first step necessary is the determination of about the interval to be used between a gauge-reading at Hermann and the occurrence of its equivalent at Saint Charles; a constant time interval has been used, and the possible error so introduced will be considered further on. An approximate value of this interval may be gotten from the hydrographs, viz, the interval between the occurrence of maximum and minimum points at the two places; beyond this approximation the method is at first mostly one of cut and try, though after having gotten the interval for a considerable distance, the interval in the same river will be found closely proportional to distance. Having gotten the interval, which in the case above is about one day, the Hermann gauge-readings are plotted as ordinates to the Saint Charles readings of one day later as abscissas and the resulting mean line gives the graphic relation, its equation, the mathematical relation between the equivalent gauge-heights for these points. The result is called a "gauge relation."

Briefly considering the error that may be introduced into this relation by the use of a constant time interval, or by a small deviation from the true time interval, this error might be considerable if only one rising stage or one falling stage were plotted for the relation; but since not only both the rising and falling stages are plotted, but many of them for a single gauge relation, the mean line will largely eliminate the error. For, suppose a time interval between two points is either altogether too long, or too long for a given stage, then, as in the case above, on a rising river the Hermann gauge will be plotted to a Saint Charles gauge too large by the rise that took place at Saint Charles in the excess of interval. On a falling river it would be too small by the fall that took place in the excess of interval, and if the rise and fall were equally rapid, there would be no error in the mean from this source. The same holds for too small an interval with the changed signs. On the stationary river there is of course no error, and at slowly changing stages it is inappreciable. In fact, the only error from error in time interval that, if existing alone, would not be eliminated in an extended series of gauge records is the possible difference of interval between the rising and falling stages; this must be very slight, probably much within the error of the gauge readings themselves. Nevertheless, on account of complications to be mentioned, it is necessary to get the time interval as closely as possible.

n what has preceded, the gauge reading has simply stood for the discharge of the er at the time of that reading, and the equivalent gauge heights have stood for same discharge at the two points. It therefore follows that all the erratic features discharge-gauge variation will be reproduced in the gauge relation, except in so as these erratic variations are exactly similar at the two points. It is important enlarge on this latter exception. All that the gauge relation does is to give differ-ces in the discharge-gauge relations. The gauge relations, from year to year, may wly change their inclination, or from one rise to another, or rapidly during a por-n of one rise; all we can say is that if one point, say Hermann, is unchangeable, at other, say Saint Charles, the discharge-gauge relation has undergone the changes wn. It is only when this chain of relatives is connected with an absolute, that is, eries of discharge measurements that absolute conditions can be given. In years en there are no discharge measurements on the river that can be taken in the chain gauge relations, the best that can be done is to take such points as have shown the st stability between other years and consider them as stable.

The case taken has been the simplest possible, since between these points, Hermann l Saint Charles, there are no tributaries to the main river. When, however, we sider a case such as the Boonville-Hermann gauge relation, it is complicated by effect on the Hermann gauge of the contributions of the Osage and Gasconade ers. If we knew the daily amount of this contribution its equivalent in gauge ght at Hermann could be subtracted from the Hermann gauge reading, and we uld then have a repetition of the Hermann-Saint Charles problem. In default of s knowledge, some knowledge of the general character of the tributaries, such as periods when floods may be mostly expected, the probable duration of same, and approximate estimate of their low-water discharge, will mostly enable us to iden-y the effect of their contributions on the gauge relation which includes them, and se portions shown free from their effect are used in determining the gauge relation ween the points; though here the gauge relation, instead of representing equal dis-arges, represents at the lower point the discharge of the upper plus the low water butary influence. As a side issue in this work the daily discharges of the tributaries at least approximately valued.

The gauge relations having been determined between all points and for all years as urately as possible, we may transfer discharge-gauge curves from points where y have been determined to other quite distant points, or by the use of the time in-vals we may plot measured discharges to distant gauges; both ways are advisable checks on each other, and all results must check with the measured discharges ere they have been taken. In fact, the use of the gauge relations for the determi-tion of discharge may disclose contradictions which necessitate their revision. This o be expected, since in the first deduction the truth is clouded by tributary action, w change in the discharge-gauge relation, and sudden erratic variation of discharge gauge, and it is only when it has met the tests that we can feel satisfied that the ht values have been assigned to these causes of divergence.

Finally, when the discharge-gauge curves have been established at the prominent nts, the scaling off the discharge corresponding to the gauge reading for every day the year is only a mechanical process.

The following is work that has been done in the line of study of the data:

PLOTTING AND STUDY OF GAUGE RELATIONS.

Hermann–Saint Charles, 1879 to 1882 and 1884.
Cedar and Jefferson City–Hermann, 1878 to 1882.
Boonville–Hermann, 1874 to 1879, and 1881 to 1882.
Kansas City–Lexington, 1875 to 1884.
Fort Leavenworth–Kansas City, 1875 to 1879.
Leavenworth–Kansas City, 1881 to 1885.
Atchison–Kansas City, 1880 to 1885.
Atchison–Leavenworth, 1879 to 1885.

DISCHARGE-GAUGE RELATIONS.

The final curve at Saint Charles, from measurements of 1879, was determined; this rve was also transferred to Hermann by gauge relation, and discharges for each day m 1873 to 1879 were scaled from same, and mean monthly and yearly discharge, in bic feet per second, made up.

The Kansas City measured discharges of 1883 and the Atchison measured discharges 1882 were plotted to the Kansas City, Leavenworth, and Atchison gauges, but final rves have not yet been determined.

Very respectfully, your obedient servant,

JAMES A. SEDDON,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

APPENDIX A 5.

REPORT OF MR. A. H. BLAISDELL, ASSISTANT ENGINEER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., July 27, 1886.

LIEUTENANT: I have the honor very respectfully to present the following report on the inspection of the Missouri river water-gauges made under your direction in May last.

On the 15th of the month, in company with Mr. James A. Seddon, I proceeded to Sioux City, Iowa, inspecting and testing each gauge in succession down the river as far as Hermann, and returned to this office on the 13th of June.

By your direction new wire-cable gauges were established on all the bridges of the river, located directly over the main channel. These give much more accurate record of the actual stage of the river than any gauge along the bank can give. A description and drawing of one of these gauges will be found at the end of this report.

A tabulated statement is also given, which shows, quite in detail, the results of the tests, heights of zeros above Saint Louis directrix, &c.

SIOUX CITY.

This is a vertical gauge of oak, spiked on a pile at the mouth of Perry Creek. It is well sheltered from injury by ice or drift, but its location is not a good one.

Perry Creek is a narrow stream and drains quite a large section of the city, and during rains is subject to sudden rises, at which times the reading on the gauge may possibly be greater by a foot than the actual height of water in the river.

I recommend that a new inclined gauge be established below the mouth of the creek.

H. E. O'Brien, a young clerk in a notion store, is the observer, and appears to be conscientious in the discharge of his duties.

OMAHA.

The only gauge found here was on a white-oak pile, graduated by nails driven into it, located at the mouth of an open sewer, about 700 feet above the bridge.

A wire gauge had previously been established on the bridge, but had been broken and not replaced.

As the standard form of wire-cable gauge adopted by you had not been received at the date of our inspection, we placed an annealed iron wire gauge on the bridge. We directed the observer, who had in his possession an extra gauge-rod, as soon as the standard gauge arrived to place it so as to read the same. This he has done, and the readings of the two gauges have since been uniform.

The observer is J. Pearson, bridge watchman, a rather loquacious but a careful and painstaking man.

The bridge is being entirely renewed, both super and sub structure, and will probably be finished in September, 1887. The bottom chord of the new bridge will be nearly 2 feet lower than that of the present one.

PLATTSMOUTH.

There are two vertical gauges here, nailed on piles, a short distance above the main street of the city—one established by the Signal Service and one belonging to this Commission. The latter reads only to 9′ and leans badly in two directions, and readings on it had been discontinued since January 3, 1886, the Signal Service gauge being substituted.

The zeros on the two gauges are nearly the same—difference, 0.26 feet.

A standard wire-cable gauge was established on the high bridge, a mile below the city, and the readings are taken daily on both gauges.

The observer is H. B. Burgess, an Episcopal clergyman and Signal Service observer, or his son, either of whom is entirely trustworthy.

NEBRASKA CITY.

This is an inclined masonry gauge, built originally very substantially. It is located over half a mile below the city, alongside of the Railroad Transfer track, and under high clay bluffs.

Frequent land-slides occur here, especially in the spring, and during heavy rains the water washes away the earth tamping on each side of the guage.

:he gauge has not yet been made perceptibly inaccurate on account of these slides, ; it must be carefully kept heavily riprapped and regularly repaired to prevent ury.
would recommend that some expense should be gone into to drain the water from bluffs away from the gauge.
)bserver is T. K. Wooster, conductor of trains crossing the transfer-boats, a reliable n.

BROWNVILLE.

:his is a vertical gauge, nailed to a pile at mouth of drain from high bluff. It is ll protected from ice and drift, and records the higher stages of water quite ac- ately. It is not extended below a 14-foot reading on account of the shallowness the water, and frequently the observer is obliged to dig a small channel through a row shore-bar to get water to the gauge. Below 14 feet he is obliged to use a tem- ary gauge, attached to a post on the edge of the bar and set from the other gauge the water surface.
can recommend no better site for the gauge, but would advise putting in a cheap lined gauge at next low-water season.
)bserver is W. H. White, a gunsmith, and a thoroughly reliable man.

WHITE CLOUD.

This is a vertical gauge, in two sections, of 10 feet each, graduated by directrix rks: a permanent high-water one, nailed to a strong pile of an old ferry landing, ich the observer uses whenever he can, even by ditching through a small shore- , get water to it. He is frequently obliged to measure down to the water surface m the 426-foot mark. In low water he uses a temporary gauge, placed near the high- ter one, attached to a post or pile and set by water surface.
would recommend a new cheap inclined gauge to be placed here.
)bserver George W. Westfall, manager of ferry-boat, &c., is a more than ordinarily eful and painstaking man.

SAINT JOSEPH.

This gauge, a vertical one, is placed in an angle of the pivot-pier of the bridge. It well protected, but on account of its location its readings must necessarily be made re or less inaccurate from the obstruction the pier causes to the free passage of the ter.
A standard wire-cable gauge has been placed on the bridge over the main channel d on the draw-span. Readings are continued from both gauges.
)bserver W. H. R. Jackson, bridge-toll collector, is an intelligent and conscientious n.

ATCHISON.

This gauge is on the upper draw-rest of the bridge, and can only be reached by a at. The current is very rapid and the eddying movement of the water is very no- eable. I do not think that it is possible for the observer to read the gauge as near two-tenths, or perhaps more, for actual water surface.
A standard wire-cable gauge was put in on the draw-span over the main channel.
Both here and at Saint Joseph Mr. S. W. Fox, and his assistant, Mr. Meredith, put the cable gauges.
Observer S. M. McCracken, bridge watchman, is satisfactory in discharge of his rk.

LEAVENWORTH.

This is an inclined oak gauge, originally put up by the Signal Service. The gradua- ns are chiseled in the wood. Eleven feet of the lower end has been broken off, and temporary expedient was adopted by nailing a 2-inch graduated pine plank on a fferent slope to the gauge at its lower end, and even then another temporary gauge s to be used for stages below the 2½ foot mark.
The gauge is in bad condition, not being "true" in any direction. The wood is tted in several places, and the rains have washed gullies on each side of it.
Steamboats, in using it as a convenient hitching-post, have also contributed to its struction. This being a very important gauge in the calculations on physical data ould receive a thorough repair or perhaps entire renewal.
Observer Charles Dill, an ex-sergeant of Signal Service, is not entirely satisfactory.

FORT LEAVENWORTH.

At this point is one of the oldest gauges on the river, established under the direc tion of Col. W. E. Merrill, United States Engineers, in connection with the Missis sippi River gauges in 1871.

It is in two sections: a high-water permanent-section bolted to the vertical roc and a very temporary section (inclined) for low water. The latter is in very bad re pair, is kept up entirely by the observer with the few facilities he has at his disposal and I would not regard it as very accurate.

The reports are sent regularly to the United States Engineer officer at Vicksburg The gauge was not tested by me.

By your direction a standard cable gauge was placed on the Leavenworth Bridge about six miles above the city, over the steamboat channel, and graduated to directrix

Observer Henry Mussett, bridge superintendent, appears to be entirely trustworthy

KANSAS CITY.

This gauge is on the upper draw-rest of the bridge and was recently replaced. Th rest is a great obstruction to the free passage of the water, causing "eddies and boils," and the readings of the gauge do not give the true height of water surface.

A standard cable gauge was placed on the draw-span over the channel, and read ings are continued from both gauges.

Observer F. D. Smith is well recommended as a careful man. His occupation i bridge agent.

LEXINGTON.

The gauges here were not in a very satisfactory condition. A high-water gauge was found at foot of the main street, leading to the river, fastened on the face of a rock culvert, which spans a creek, graduated from 6 feet to 22 feet.

In front of the gauge, extending out about 75 feet, is a shore bar. From its loca tion I do not think any careful calculations ought to be based on this gauge-reading.

Over half a mile below, near the ferry landing, is the low-water sloping gauge of 2-inch plank on edge, which can only be called temporary, as it is liable to be destroyed by drift. It is graduated from 8 feet to 2 feet *above* low water.

These two gauges were established from different bench-marks, and in running two careful lines of levels between the benches we found a discrepancy in the published elevations of $+0'.148$ in B. M. No. 189.

Deeming it impossible to correlate the readings of these two gauges, we established a sloping gauge for high water, located 100′ above the low-water one, graduated from 5 feet upwards.

It consists of 6″×6″ white pine timber set on 6″×8″ posts, firmly sunk; earth well tamped and moderately well riprapped with stone. It has the same zero as the low-water gauge, and its readings have been satisfactory.

The new gauge, although cheaply made, I esteem a very good one; it will require, however, attention to prevent the surface water from undermining it, and this the regular observer can readily do.

I would recommend that this gauge be either extended to low-water mark or an entire new one be made (the latter preferable).

Observer Newton Gibson, omnibus driver, is an unusually intelligent man.

WAVERLY.

This is a very well built inclined masonry gauge, and is correct within the limits of accuracy of reading. The iron bar on the wooden beam is somewhat uneven, proba bly due to expansion, but not sufficiently so to need repair. The location, although somewhat inconvenient of access, could not be improved.

Observer B. H. Thomas, a dry-goods merchant, is fairly efficient.

DE WITT.

This is also a masonry inclined gauge, in good order, but unfortunately located at the present time, as a narrow shore-bar is formed in front of it, necessitating frequent ditching to get the water to the gauge.

In lower stages of water a temporary gauge, nailed to a post or log, has to be re sorted to.

Observer J. N. Carson, railroad station agent, appears to be a careful man.

GLASGOW.

This was found to be a counterbalanced iron-wire gauge on the north side of the river ıd on the first deck-span approached from the south. The gauge wire is No. 10, B. '. G., and a weight of thirty pounds was attached to it. It was found reasonably ›rrect, but its location is such that during the lower stages of water the bar becomes ıtirely dry underneath it.

The gauge is far from the main channel, and the only reason for placing it there ›uld have been to keep the counterpoise or gauge-weight out of the way of passing ›amboats.

In low water the observer adopted the expedient of lowering a weight from a sheave ı the top chord of the bridge.

A standard wire-cable gauge was placed over the main channel, and showed a differ- ıce of .033 in height of water surface from that given by the old gauge.

Observer Aris B. Sherwood, bridge attendant, is entirely satisfactory.

BOONVILLE.

This gauge, although found to be in very good order, and nearly correct as regards ; zero, is open to the same objections which obtains to all gauges which are attached draw-rests or any other obstruction to the free passage of water.

A standard cable gauge was established over the main channel on the draw-span ' the bridge, and readings on both gauges ordered to be continued, in order to note ıe probable error of the vertical gauge.

Observer C. Randecker, watchman on the bridge, is fairly competent.

JEFFERSON CITY.

The gauges here are not very satisfactory. The high-water gauge is on the face of a ıilroad culvert, spanning a good-sized creek, and its readings, when the creek is high, ınnot give the true height of water in the river. The low-water gauge is a temporary oping one, located about 1,800 feet above. It has served its purpose very well and ›obably will remain until next winter, but no absolute connection between the two ıuges can be made at different stages of water.

It is recommended that a new inclined gauge be placed in the locality of the low- ater one at an early day.

Observer D. W. Rogers, collector on ferry-boat, appears to be a very conscientious ıan.

HERMANN.

This is a Signal Service gauge, receiving no attention except that given it by its ob- ›rver, Mr. Maushund. It is made of 2-inch plank on edge, and nailed to small posts. ; is quite well protected by large rocks, or it would have been swept out by ice or rift. The lower end has been repeatedly broken off and been replaced by the observer. s this gauge has proven of benefit in investigation of physical data, it is recom- ıended that a permanent inclined gauge be established here.

SAINT CHARLES.

This was the first standard wire-cable gauge established by your order on the Mis- ›uri River bridges. It was not inspected, but the observer, J. S. Hill, bridge watch- ıan, a very careful and intelligent man, reports that he has kept a mark on the guard- ıil of the bridge which would show any variation in the length of the cable, and hat no appreciable difference can be observed since the gauge was put up in March.

DESCRIPTION OF STANDARD WIRE-CABLE-BRIDGE GAUGE.

This is a very simple gauge, as the sketch herewith shows, and probably the most ›liable of all the gauges on the river.

The component parts are a deeply grooved iron sheave with a lag screw and wash- rs to fasten it to a stringer, guard-rail end of tie, or any convenient timber; a suf- cient length of best Swedish iron wire sash cable of ¼ inch diameter, running over he sheave, to one end of which is fastened a weight varying with the length of the ord, generally a window-sash weight of 14 to 16 pounds, and to the other end is at- ached an iron handle with an index cross-piece and a turnbuckle and lock-nut for aking up any stretch that may ensue from long use of the gauge. Next is a prop- rly graduated gauge-rod fastened horizontally to the same stringer or guard-rail that he sheave is attached to, with its zero properly placed. In making an observation he observer simply lowers the weight until it touches the water and takes his reading.

The contact with the water surface can be made quite accurately, especially if the un casts a shadow from the weight.

After the reading is taken the observer walks back with the entire line and weight until the latter is sufficiently high to be out of the way of passing steamboats or until it is up to the bottom chord of the bridge and secures the handle to a spike or staple and locks it thereto, if he deems it necessary.

It was at first thought that the size of the cable (¼-inch) would present too great a wind surface, but it has been found that, even in quite heavy winds, it does not become enough curved to vitiate an observation.

It is also found that the cable, while it is much stronger and more durable than iron or other wire, does not stretch, except to a very small extent, under the continued strain of a heavy weight.

Very respectfully, your obedient servant,

A. H. BLAISDELL,
Assistant Engineer.

Lieut. T. A. BINGHAM,
Corps of Engineers,
Secretary Missouri River Commission.

Tabular statement.

Location.	Gauge.	Elevation.		Remarks.
		Zero.	Foot marks.	
Sioux City	Vertical	Datum		
Omaha	Pile	544'.804		
Do	Wire	544'.804		
Do	Cable	544'.804		
Plattsmouth	Vertical U. S. E	527'.948		
Do	Vertical S. S	528'.212		Readings commenced January 3, 1886.
Do	Cable	525'.893		
Nebraska City	Inclined masonry		501'=500'.863 502'=501'.862 503'=502'.860 504'=503'.852 505'=504'.837 506'=505'.845 507'=506'.844 508'=507'.855 509'=508'.862 510'=509'.868 511'=510'.886 512'=511'.916 513'=512'.942	
Brownville	Vertical	457'.496		
White Cloud	do	+0'.027		
Saint Joseph	Cable	Datum		
Atchison	Vertical	+0'.030		
Do	Cable	Datum		
Kansas City	Vertical	Datum		
Do	Cable	Datum		
Lexington	Vertical H. W	254'.581		These elevations are referred to B. M. No. 190. B. M. No. 189 appears to be 0'.148 higher than printed elevation.
Do	Inclined L. W	254'.824		
Do	Inclined H. W	254'.820		
Leavenworth	Inclined S. S		X'=338'.387 XI'=339'.391 XII'=340'.390 XIV'=342'.361 XVI'=344'.315 XVIII'=346'.293 XX'=348'.318 XXII'=350'.323 XXIV'=352'.323 XXV'=353'.319	
Do	Cable	Datum		
Waverly		229'.913		
De Witt		201'.308		
Glasgow	Old wire	82'.383		
Do	Cable	82'.350		
Boonville	Vertical (new)	153'.164		
Do	Cable	153'.274		
Jefferson City	Vertical H. W	30'.75		
Do	Inclined L. W	30'.76		
Hermann	Inclined S. S	70'.80		

Appendix A 6, showing stages of the Missouri River, from Saint Charles, Mo., to Fort Pierre, Dak., compiled from miscellaneous and regular gauge records, between 1872 and 1885, was printed in House Ex. Doc. No. 28, Forty-ninth Congress, second session, and is here omitted.

APPENDIX A 7.

REPORT OF FIRST LIEUTENANT T. A. BINGHAM, CORPS OF ENGINEERS.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., April 1, 1886.

SIR: In connection with the survey of the Missouri River, now under way, by direction of the Commission, question arose as to the reliability of the elevations determined in past years; because the instruments used had been wye levels with New York rods, whereas the so-called "precise" leveling of the Mississippi River Commission had been done with Kern instruments and self-reading rods. The Coast and Geodetic Survey people, who are engaged upon a transcontinental line of levels, have advanced as far west of Saint Louis as Etlah, Mo., a station on the Missouri Pacific Railroad. For nearly 20 miles (from South Point to Etlah) their line lies along the right bank of the Missouri River where there are many of the U. S. E. bench-marks.

It was deemed best to send a party into the field to level over this 20 miles for two objects, viz:

(1) By connecting the U. S. E. and C. S. bench-marks to get a check on our own elevations.

(2) To determine how closely to a line of "precise" levels a line can be run with a wye level, the Coast Survey method and that of the M. R. C. being substantially the same.

The party started February 8, and returned March 6. The work cost $365, not including salaries of assistant engineer and rodman, who were taken from the office force. Mr. Warren's report is appended.

While the party was absent in the field it was discovered that P. B. M. 12, of the Mississippi River Commission, at the mouth of the Missouri River, on which all the U. S. E. elevations depend, had not been finally determined when elevations were printed. Taking the figures given in Mississippi River Commission Annual Report for 1883, the correction to be applied to all our elevations is $+ 0'.341$.

The accompanying diagrams were prepared by my direction to illustrate different methods of comparison.

Referring to sheet 1 and regarding the connections between the U. S. E. and C. S. benches, as accomplished without error, column 21 gives the differences between our corrected elevations and the Coast Survey elevations for the same bench-marks.

$$10^{mm} \sqrt{\text{dist. in kilometers}} \text{ (or } 0'.041621 \sqrt{\text{dist. in miles}}\text{)}$$

is the limit of discrepancy allowed in the Lake Survey (see Prof. Pap. Corps of Engineers, No. 24, p. 598).

In the instructions for precise leveling, prepared by Mr. L. L. Wheeler, under the direction of General Comstock (Report Chief of Engineers for 1880, p. 2433), the limit of allowable discrepancy was given as

$$5^{mm} \sqrt{\text{dist. in kilometers}} \text{ (or } 0'.02081 \sqrt{\text{dist. in miles.}}\text{)}$$

In the Annual Report Mississippi River Commission for 1883, p. 143, will be found the deduction, by Mr. L. L. Wheeler, that cumulative errors are "nearly if not quite proportional to the distance leveled, instead of the $\sqrt{\text{dist.}}$"

In Appendix 11, Coast Survey Report for 1882, p. 522, is found the following note:

"With respect to leveling of precision executed of late years in Europe, in the opinion of the Geodetic Association a probable error in the resulting difference of height as large as $\pm 3^{mm}$ per kilometer (0'.01584 per mile) may still be tolerated, but one of $\pm 5^{mm}$ (0'.0264 per mile) would be considered as surpassing an allowable limit. A value of $\pm 2^{mm}$ (0'.01056 per mile) may be considered to represent a fair measure, and one of $\pm 1^{mm}$ (0'.00528 per mile) a measure of high precision."

The severest of these limits is the second given, which is the one adopted by the Mississippi River Commission.

Applying these tests to column 21, we find that all but one of the differences are within the severest limit.

Since the U. S. E. levels were carried down the river from Sioux City, differences shown in column 21 are quite satisfactory.

There is one difference that does not fall in line, but uncertainty exists as to the exact bench-mark in this case.

It seems as if a constant error appeared in these differences as they stand. This constant is not yet satisfactorily explained. It may never be, but it is proposed to

look into the matter carefully. P. B. M. 12, above referred to, will be re-examined, test levels will be run, the original notes will be re-examined and computed, &c.

All the notes of the U. S. E. levels have been examined by Mr. L. L. Wheeler, who reported that they were not susceptible of mathematical discussion, because the methods followed excluded independence in checking. His reports are appended.

This is unfortunate; but the method was one adopted necessarily by force of circumstances, and, as shown above, has been productive of very good results. Although the notes cannot be discussed, these results are certainly entitled to full credit unless disproved in future.

All that is immediately necessary is to correct our printed list for an error for which the U. S. E. Department is not responsible.

Now, as to the second point to be determined, we have the following facts:

(1) The "loop" agreed with the Coast Survey line and itself within 0′.011 over the entire distance, both up and down, of 40 miles. This is within the severest limit given above.

(2) The greatest difference of the mean (or checked) line from the Coast Survey was 0′.023, which occurred in a distance of about 23 miles. This is also within the severest limit.

(3) The greatest difference between the 1886 and C. S. line anywhere was 0′.05, also within the severest limit.

All this is a very good showing for the wye level, and serves to increase confidence in the work done by it under what may be called the Missouri River method.

It is believed that no other lines of levels so extensive have been run with the so-called "ordinary" instruments, nor any lines done with wye levels subjected to such minute and detailed care in the use of instrument and rod and in methods of observation. Full details of methods were given in report of secondary triangulation, dated March 1, 1885.

It is to be noted, also, that conditions of weather were very unfavorable when this comparison was made, as Mr. Warren explains in his report.

Again, with precise levels, properly conducted, work is done only for an hour or so in the morning and another hour or so in the evening, while this comparison was made by steady work all day when weather permitted.

We have, then, very good reason to abide by our elevations as at present determined, unless, as before remarked, future checks discover material errors.

But all this is by no means an argument against precise levels; merely an argument against discrediting those already determined on the Missouri River and to replace which will cost a large amount of money.

The following table shows the results obtained by the levels already run from the mouth of the river to Pierre, Dak., a total distance of 1,170.7 miles.

Year.	Place.	Miles.	Check.	Maximum difference at any point.	$0'.021 \times \sqrt{\text{dist. miles.}}$	0′.0063 per mile.
				′	′	′
1880	Sioux City, Iowa–Lexington, Mo.	483.5	Independent levels connecting with same bench-marks.	0.182	0.458	2.553
1881	Lexington, Mo.–mouth Missouri River	319.3		.173	.372	1.686
1881	Fort Randall, Dak.–Sioux City, Iowa	179		.082	.278	.945
1882	Pierre, Dak.–Fort Randall, Dak	190		.154	.287	1.001
1885	Upper Missouri River (continuous check-levels)	17		.021	.086	.0696

Column 6 shows the amount of error allowable by the severest test, viz: That of the Mississippi River Commission—

$$5^{mm} \sqrt{\text{dist. in kilometers}} \text{ (or } 0'.021 \sqrt{\text{dist. in miles}}\text{).}$$

It may be objected that this test cannot be applied to levels run as the Missouri River levels were run. This is a fair objection; but as the first line and its check were never at any time farther apart than indicated in column 5, the application of the test shows the degree of care with which the line was run; and it has been before shown that the elevations as they stand are worthy of credit, although not susceptible of discussion.

Very respectfully, your obedient servant,

THEO. A. BINGHAM,
First Lieut. of Engineers,
Secty. Mo. River Commission.

Maj. C. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

OFFICE OF MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., March 3, 1886.

SIR: I have the honor to report that I have examined the notes of the levels along the Missouri River from Sioux City to the mouth of the river.

I find that, on each of the four sections, into which the work was divided, the terminal differences between the two lines of levels were very small, in fact much smaller than many of the differences arising between successive bench-marks. It is evident from the notes that a partial adjustment between the two lines of levels has been made in the field, and that the two measurements are not entirely independent on that account.

I submit herewith two sample tables, the first of which would give as good an idea of the precision of the work as can be obtained, but would indicate greater precision than the work possesses on account of the partial adjustment which has taken place.

In case that it was desired to publish the data the second form should be used, and elevations with reference to the Saint Louis City directrix given. It would require very little labor to make the first table, but it would have the disadvantage of not being finally of much use. The second form would require about twice the labor of the first.

In regard to a recomputation of the notes, the value of such recomputation could only be known after it had been made. I have noticed, in looking over the notes, a few small errors of computation, but none that would materially change the elevations. In one instance, however, I noticed a discrepancy of five feet between the two lines of levels for which no explanation appears in the notes.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers U. S. A.,
Secretary Missouri River Commission.

FORM No. 1.

Bench-marks.	Elevations.		First elevation.	Second elevation.	Discrepancy between successive bench-marks.
	First party.	Second party.			

FORM No. 2.

Bench-marks.	Difference of elevation.			Elevation above Saint Louis directrix.	Discrepancy.	
	First party.	Second party.	Mean.		Partial.	Total.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., March, 4, 1886.

SIR: I have the honor to report that I have examined the notes of the levels between Pierre and Sioux City.

I find that the same adjustment has been made in this section as between Sioux City and the mouth of the river. This work has been done by two parties, leveling alternate portions, each party consisting of two levelers. Whenever a new division has been commenced a new datum has been assumed and elevations along that portion of the river given with reference to that datum. On this account it would not be

possible to make a table like Form 1, previously submitted, without either performing some computation or including in the table the pegs on which divisions joined.

On account of the number of datum planes to which elevations along this portion of the river have been referred, errors of computation are more likely to have occurred, and hence recomputation is probably more necessary than in the portion below Sioux City.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., March 22, 1886.

SIR: In pursuance of your instructions, issued early in February, "to organize a party and proceed to the vicinity of South Point and Etlah, Mo.," both places being on the Missouri River and on the line of the Missouri Pacific Railroad, and "run a duplicate line of check-levels between bench-marks of the U. S. Coast and Geodetic Survey of 1882, which were located near the places named," I, on the morning of February 8, 1886, left the city with the following party: Mr. E. L. Cooley, assistant engineer, acting rodman, one shademan, and two axmen. Upon arriving at Washington, Mo., 10.46 a. m., work was at once begun, putting instruments, rods, and shades in condition for active work.

Owing to an indefinite description of the Coast and Geodetic B. M. XII, which should be near South Point, and pending a further and more accurate description, work was commenced from the C. & G. B. M. L 3, located on the German Catholic Church at Washington, Mo. A line was carried down the hill connecting with the Missouri River Survey Bench Marks "74" and "75", of 1879, and thence west along the line of the Missouri Pacific Railroad, connecting with such bench-marks of previous levels as could be found. The work was continued westward, or up-stream, until near New Haven, some 12 miles, when, the desired description of the C. & G. B. M. XII having been obtained, connection between the C. & G. Bench Marks L 3 and XII was made, a distance of some 2¾ miles, and a return or check-line run with the following results, as compared with the C. and G. line:

My first line down, from L 3 to XII, gave the elevation of XII as +0'.002 above the C. & G. The return line gave an elevation for L 3 of +0'.005 above the C. & G., a difference between my two lines of +0'.007.

Work was then resumed westward from near New Haven, and at the latter place connection was made with the C. & G. B. M. "M 3," giving a difference of +0'.042 over the C. & G. line.

The line concluded to Etlah, some 18 miles from B. M. XII, gave a difference of +0'.025 above the recorded C. & G. elevation of B. M. XIV, as a result of the continued line, connection having been made as stated with B. M. L 3.

Many difficulties were encountered in this line. The frosty and thawing ground, the sudden changes in temperature, from bright sunshine to freezing and rain and snow, made work at times very difficult. The constant watch of the instrument and utmost care was necessary to secure fair readings.

Returning, the work was taken at Etlah and carried on down-stream under more favorable conditions, both of ground and weather, a cloudy sky and mostly even temperature prevailing. The results of the two lines were as follows, comparisons being made with the Coast and Geodetic elevations:

	Bench-marks.			
	XII.	L 3.	M 3.	XIV.
C. and G. elevation, 1882	76.451	131.838	95.644	95.415
My first line	76.451	131.903	95.686	95.4[illegible]
My second line	76.455	131.900	95.652	95.415
Difference, first line (up)	0.000	+0.005	+0.042	+0.0[illegible]
Difference, second line (down)	+0.004	+0.002	+0.008	+[illegible]

The Coast and Geodetic Bench Mark XII, and the Missouri River Survey Bench Mark 41, were found to be the same; the C. and G. giving the elevation of the same

s 76.451, and the Missouri River Survey as 76.250, both derived from the Saint Louis City Directrix as 0.000.

Connection was made on both lines with Missouri River Bench Marks 41, 42, "74," and "75," of 1879, 46, 47, 48, 50, and 51.

The table of differences and profiles accompanying this report shows the relative bearings and different elevations of all bench-marks as derived by the several different lines. Bench-marks were established on the stone wing-wall or abutment, of a double-track culvert about 1 mile above Washington; a second on the permanent pier, or abutment of Saint John's Creek, 2¼ miles above Washington, and a third on a substantial sandstone covered culvert over the Little Bœuf Creek at Dundee. The elevations and descriptions of the same are attached to the sketches hereto attached.

These bench-marks are intended to take the place of bench-marks destroyed, several of those of the Missouri River Survey not being found.

The instrument used on this work was a Buff & Berger Y-level, "No. 391," and New York rod and target, such as are in common use on the surveys of the Missouri River. Attached to the rod was a movable universal bubble or level, which enabled the rodman to keep the rod vertical.

Equal back and fore sights were taken, usually 300 feet, the regularity of telegraph poles being tested, the distance between two being used. After setting up the instrument, and good and substantial pegs or turning points having been secured, the rodman gave the leveler two or more readings and settings of target, or until two readings would not show a difference to exceed 0′.001, the target in each case being moved up or down and the same method used as that in use on the leveling of the Missouri River Survey, as to a constant check between the leveler and rodman of elevations, heights of instrument, and rod readings. A record of each reading was kept by the rodman, which will give a fair indication of the differences of temperature, sunshine and shadow, and cloudy and even temperature.

Under specially good conditions of air and temperature two lines and check were run, in which the rod readings are an indication of the steadiness of the atmosphere. The first, a line starting one-half mile below Washington, was run down 1¼ miles to B. M. XII and returned the same day, a check of 0′.003 being the result; while the line between B. M. XII and 42, a mile, was run and repeated with an absolute check.

A duplicate line, run between B. M. 47 and 46, on my check-line for verification gave even better results, the distance 1¾ miles, check 0′.001. In both these instances the recorded readings will show but few instances of more than two settings of the target to meet the requirements of 0′.001.

The C. & G. Bench Mark XIII, at New Haven, was not found, it having been destroyed in repairs on the culvert by the railroad company.

A correction of +0′.341 having been received from the Mississipi River Commission, such will have to be added to elevations of bench-marks of the Missouri River Survey of 1881, and would make the elevation of B. M. 41 = 76′.591.

Sheet 1, accompanying this report, shows a complete tabulation of the different lines run.

Sheet 2.—Profile, referring the Coast and Geodetic line, and Missouri River Survey line of 1881, to the mean line of this survey.

Sheet 3.—Profile, referring the two previous lines and the down-stream line of this survey to the up-stream line of same.

Sheet 4.—Profile, showing line as started at C. and G. B. M. XII, returned in a "loop" with the two previous lines referred to up-stream line of this survey.

I have the honor to be, your obedient servant,

ALBERT WARREN,
Assistant Engineer.

First Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

SHEET 1.

Number of station.			Distances, in feet, from South Point "up-stream."	Missouri River, 1886, "up-stream."		Missouri River, 1886, "down-stream."			Missouri River, 1886. Mean elevation referred to XII as origin.	Elevations, U. S. Coast and Geodetic Survey, 1882.
U. S. Coast and Geodetic Survey, 1882.	Missouri River, 1881.	Missouri River, 1886.		Elevations, in feet, from field notes.	Referred to South Point, XII, as origin.	Elevations, in feet, from field notes.	Referred to South Point, XII, as origin.	Referred to "up-stream" as origin.		
1	2	3	4	5	6	7	8	9	10	11
XII.	41	XII=41	1,000	76.451	76.451	76.453	76.451	76.496	76.451	[illegible]
	42	42	6,200	73.115	73.115	73.117	73.115	73.160	73.115	....
	....	2′	9,200	72.512	72.512	72.511	72.509	72.554	72.511	....
	....	1′	11,300	72.956	72.956	72.944	72.942	72.987	72.949	....
	"75"	"75"	12,670	83.730	83.730	83.717	83.715	83.760	83.723	....
	"75"	"75"	....	83.717	83.730	....	....	....	....	
L 3.	....	L 3	....	131.890	131.908	....	....	....	....	131.[illegible]
L 3.	....	L 3	....	....	....	....	....	....	131.907	....
L 3.	....	L 3	....	131.898	131.911	....	....	....	....	131.[illegible]
	"75"	"75"	....	83.717	83.730	....	....	....	....	....
	"75"	"75"	12,670	83.717	83.730	83.747	83.715	83.760	83.723	....
	....	1	15,200	77.306	77.319	77.336	77.304	77.349	77.312	....
	....	2	16,100	76.447	76.460	76.483	76.451	76.496	76.456	....
	....	3	20,200	78.506	78.519	78.522	78.490	78.535	78.505	....
	....	5	25,900	80.754	80.767	80.771	80.739	80.784	80.753	....
	(Peg 40=114)		29,500	83.387	83.400	83.340	83.308	83.353	83.354	....
	....	7	82,900	80.517	80.530	80.527	80.495	80.540	80.513	....
	....	8	39,800	85.443	85.456	85.501	85.469	85.514	85.463	....
	....	9	44,000	89.978	89.991	90.015	89.983	90.028	89.987	....
	(Rock 72=81=10)		49,800	87.473	87.486	87.521	87.489	87.534	87.488	....
	46	46	50,200	98.176	98.189	98.238	98.206	98.251	98.198	....
	....	10	52,600	87.631	87.644	87.662	87.630	87.675	87.637	....
	(Rock 86=3)		56,600	90.414	90.427	90.428	90.306	90.441	90.412	....
	(Peg 87=2)		57,200	88.926	88.939	88.946	88.914	88.959	88.927	....
	47	47	58,400	87.113	·87.126	87.138	87.101	87.146	87.114	....
	48	48	66,200	94.454	94.467	94.476	94.444	94.489	94.456	....
	(Peg 103=51)		66,800	91.070	91.083	91.097	91.065	91.110	91.074	....
	(Stone 104=50)		67,400	90.208	90.221	90.235	90.203	90.248	90.212	....
	(Peg 105=49)		68,000	90.808	90.821	90.838	90.806	90.851	90.814	....
	....	11	69,200	88.288	88.301	88.312	88.280	88.325	88.291	....
	(Stone 113=42)		72,100	91.641	91.654	91.653	91.621	91.666	91.638	....
	....	12	75,700	89.699	89.712	89.693	89.661	89.706	89.687	....
	(Culvert 121=31)		77,600	91.110	91.123	91.103	91.071	91.116	91.097	....
M 3.	....	M 3	79,000	95.681	95.694	95.672	95.640	95.685	95.667	95.6[illegible]
	50	50	79,000	96.377	96.390	96.367	96.335	96.380	96.363	....
	....	13	79,300	92.852	92.865	92.835	92.803	92.848	92.834	....
	(Stone 134=20)		84,300	93.737	93.750	93.737	93.705	93.750	93.728	....
	(Stone 136=18)		85,500	95.475	95.488	95.478	95.446	95.491	95.467	....
	(Peg 138=16)		86,700	94.236	94.249	94.245	94.213	94.258	94.231	....
	....	14	87,700	94.227	94.240	94.241	94.209	94.254	94.225	....
	51	51	89,800	92.480	92.493	92.493	92.461	92.506	92.477	....
	(Stone 152=2)		95,100	95.411	95.424	95.412	95.380	95.425	95.403	....
XIV.	....	XIV	96,300	95.435	95.448	95.435	95.403	95.448	95.426	95.4[illegible]

SHEET 1—Continued.

Number of station.			Missouri River, 1881.			Differences from 1886, "up-stream."				Differences from 1886, mean elevations. Referred to XII as origin at South Point.		
						Referred to XII as origin.			Referred to XIV as origin. "Down-stream."			
U. S. Coast and Geodetic Survey.	Missouri River, 1881.	Missouri River, 1886.	Elevations from list printed 1883.	Elevations referred to XII as origin.	Elevations from list corrected, 1886.	"Down-stream."	U. S. Coast and Geodetic Survey.	Missouri River, 1881.		U. S. Coast and Geodetic Survey.	Missouri River, 1881.	Missouri River, 1881, corrected, 1886.
1	2	3	12	13	14	15	16	17	18	19	20	21
XII.	41	XII=41	76.250	76.451	76.591	.000	.000	.000	+.045	.000	.000	+.140
	42	42	72.942	73.148	73.283	.000		+.028	+.045		+.028	+.168
		2'				—.003			+.042			
		1'				—.014			+.031			
	"75"	"75"	83.573	83.774	83.914	—.015		+.044	+.030		+.051	+.191
	"75"	"75"	83.573	83.774	83.914							
L 3.		L 3					—.005					
L 3.		L 3								—.009		
L 3.		L 3					—.013					
	"75"	"75"	83.573	83.774	83.914							
	"75"	"75"	83.573	83.774	83.914	—.015		+.044	+.030		+.051	+.191
		1				—.015			+.030			
		2				—.009			+.036			
		3				—.029			+.016			
		5				—.028			+.017			
	(Peg 40=114)					—.092			—.047			
		7				—.035			+.010			
		8				+.013			+.058			
		9				—.008			+.037			
	(Rock 72=81=16)					+.003			+.048			
	46	46	97.986	98.187	98.327	+.017		—.002	+.062		—.011	+.129
		10				—.014			+.031			
	(Rock 86=3)					—.031			+.014			
	(Peg 87=2)					—.025			+.020			
	47	47	86.900	87.101	87.241	—.025		—.025	+.020		—.018	+.127
	48	48	94.249	94.450	94.590	—.023		—.017	+.022		—.006	+.134
	(Peg 103=51)					—.018			+.027			
	(Stone 104=50)					—.018			+.027			
	(Peg 105=49)					—.015			+.030			
		11				—.021			+.024			
	(Stone 113=42)					—.033			+.012			
		12				—.051			—.006			
	(Culvert 121=34)					—.052			—.007			
M 3.		M 3				—.054	—.050		—.009	—.023		
	50	50	96.246	96.447	96.587	—.055		+.057	—.010		+.084	+.224
		13				—.062			—.017			
	(Stone 134=20)					—.045			.000			
	(Stone 136=18)					—.042			+.008			
	(Peg 138=16)					—.036			+.009			
		14				—.031			+.014			
	51	51	92.272	92.473	92.613	—.032		—.020	+.013		—.004	+.130
	(Stone 152=2)					—.044			+.001			
XIV.		XIV				—.045	—.033		.000	—.011		

APPENDIX A 8.

REPORT ON THE COMMERCE OF THE MISSOURI RIVER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., June 30, 1886.

SIR: In accordance with the directions of the Commission, that the "secretary procure statistics as complete as possible of the commerce of the Missouri River," I have the honor to report as follows:

The results of my endeavors to collect data, reaching to date, and full, have been very meager.

Letters and lists of exact information wanted were sent to all addresses that could be heard of as likely to prove fruitful. Very few answers were received, and these very incomplete. Steamboat men are very unwilling to give definite information as to the trade of their companies, apparently from fear of the railroads. Even when assured that their disclosures would be kept confidential, their caution refused to be overcome.

It has been impossible, too, to get a statement of the money-value of the commerce of the river. What values are given for the upper river are merely guesses, and for the lower river, Mr. George H. Morgan, secretary of the Saint Louis Merchants' Exchange, tells me they have no values, and he does not know how to suggest a method of getting at them.

At the present time the river is divided into two almost distinct sections as regards its navigation, viz, the Lower River, from its mouth to Sioux City; and the Upper River, from Sioux City up. Saint Louis is the principal home-port for the Lower River, and Bismarck for the Upper. There is, besides, a number of steamers, mostly quite small, engaged as ferries, or in a limited coasting trade.

Tables 1, 2, and 3 give a list of steamboats authorized to ply on the Missouri River, with all the details that could be learned. The list is mainly from custom-house records. There are 59 in all. Of these, 19 belong wholly to the Upper, and 18 wholly to the Lower River. The rest are scattering.

Tables 4, 5, 6, 7, and 8 give the latest obtainable returns as to population and products of the river counties along the Missouri, the idea being that the river counties might be regarded as constituting the main portion of the Missouri Valley, and especially as the portion tributary to the river. Some of the tables have returns for one year only, and others have returns for several years. But it will be seen, by the percentages given between river counties and the entire State, or territory, that the country along the river is falling off in its percentage of increase, as compared with sections farther removed from the river. This is natural enough. For as long as the river was the only highway, settlement and production clung to its banks. As railroads were pushed, new avenues for immigration were opened, and the river country fell off, when compared with a whole State or territory, while, as a single highway, it has kept its own.

LOWER RIVER.

Only 3 boats did through business in 1885, viz, Dacotah, Carroll, and Meade, of the Saint Louis Electric Packet Company, Jenkins & Sass, agents.

Their down-stream business was good, but not as good as in 1884, attributed to failure of crops and the reduced acreage sowed to wheat and corn, which, with lumber and some stock, constitute the usual down-stream cargo. The up-stream cargo is general merchandise.

During the season of 1885 these three boats carried 115,000 tons of through freight up-stream to Kansas City and Saint Joseph, and 20,000 tons of way freight; total, 135,000 tons.

The down-stream freight was 50,000 tons. Total moved during the season, 185,000 tons.

Taking 20,000 pounds, or 10 tons, as a car load, and counting 30 cars to the train, we have 617 trains as necessary to move 185,000 tons of freight, or one train a day each way for every day in the year excepting Sundays.

Forty round trips were made by these boats during the season, from Saint Louis to Kansas City, and three of these trips were continued to Saint Joseph.

Of these boats the Dacotah and Carroll can carry, so their agents say, from 1,000 to 1,200 tons. Their average load, down-stream, was 800 tons grain and 350 head stock; up-stream 500 to 1,000 tons.

No barges are towed on Lower Missouri—they cannot be insured.

Up-stream business was best in 1885; down-stream, in 1884. Rates of insurance, Saint Louis to Kansas City, 1885, 2 per cent.; 1884, 1 per cent. Tariff per 100 pounds of grain, 1885, 10 to 15 cents; 1884, same.

Capt. James Kennedy, of Kansas City, says:

"With good crops of corn and wheat there is plenty of business between Saint Joseph and Saint Louis still for three or four good boats, both up and down stream. This leaves out the handling of grain at Kansas City and Saint Joseph, supposing the railroads to control those points."

The above corroborates the following extract from the Annual Report of the Saint Louis Merchants' Exchange for 1883, p. 29.

"The Missouri River business, though apparently declining in relative importance, is still of value, and worthy of more careful and systematic cultivation. The construction of railroads environing both banks of this river has cut off a large part of the trade formerly carried by steamboats; but there is still much which is and will be reached by them alone, and from which a limited number of boats can be well sustained.

"It is confidently believed that at some future date the channel of this river will be so much improved that a much larger proportion of the heavier products of the adjacent country will seek a market over its waters."

In this connection the following facts may not be too old:

In 1878 the Mississippi Valley Transportation Company sent 3 empty barges to Kansas City. They started back July 5, with 83,450 bushels of corn. They had no mishap, but the barges were too large for the Missouri.

The Babbage Transportation Company followed with 3 better barges, which came up empty three times and took away, July 27, 62,038 bushels corn; August 12, 62,938 bushels corn; August 31, 44,198 bushels wheat. They had no mishap, but were stopped during August by low water. Totals, 208,516 bushels corn, 44,198 bushels wheat.

Although the barges were empty one way, they cleared 100 per cent. profit for the owners.

It will be observed that the barge business was stopped by low water. This is where the advantage of river improvement comes in, for low water occurs just about harvest time.

Table 9 shows the relation of the Missouri River trade to the entire railroad business of Saint Louis for the eleven years, 1874 to 1885. It will be noticed that the percentage gets slowly smaller, being for 1885 about 0.2 per cent.

Table 10 shows the relation between the Missouri River trade and its competing railroad lines for the ten years ending 1885. During all these years its trade has been very small, in the light of this comparison, and of late years it has been pretty steady at 2 to 2.5 per cent.

Table 11 is substantially table 10 itemized, and shows the character of the Lower River commerce.

Table 12 gives certain statistics of the business done at Leavenworth, Saint Joseph, and Omaha.

In 1879 the products of the Missouri River Valley were (call for convention, Kansas City, November 1885): wheat, 61,116,377 bushels; corn, 414,349,526 bushels.

The following table shows the products of the river counties for 1880, in round numbers (Census Reports):

State or Territory.	Population.	Corn.	Oats.	Rye.	Wheat.	Barley.
		Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Missouri	554, 000	61, 685, 000	6, 000, 000	164, 000	11, 000, 000	87, 000
Kansas	92, 400	7, 000, 000	638, 000	21, 000	1, 500, 000	44, 000
Nebraska	130, 000	23, 000, 000	1, 750, 000	108, 000	2, 200, 000	400, 000
Iowa	112, 000	25, 500, 000	1, 100, 000	54, 000	1, 650, 000	200, 000
Montana	17, 200	1, 500	500, 000	....	280, 000	27, 000
Dakota	81, 000	1, 070, 000	400, 000	4, 800	221, 000	42, 000
Total	936, 600	118, 256, 500	10, 388, 000	351, 800	16, 851, 000	800, 000

The totals in this table are smaller than those given above for 1879, because in the table only the river counties are considered, and in the others the entire country drained by the Missouri River.

For Missouri (Table 4) I have no details later than 1880.

For Kansas I have details for 1883 and 1884 (Table 5), and deduce the following yearly percentages of increase over 1880, to be used in calculating a table for 1885.

Population	per cent..	3
Corn	per cent..	5
Oats	per cent..	15
Rye	per cent..	75
Wheat	per cent..	16

For Nebraska I have details for 1885.

For Iowa I have no details later than 1880.

For Montana I have details for 1883, and deduce the following yearly percentages of increase, over 1880, to be used in calculating a table for 1885.

Corn	per cent..100
Wheat	per cent.. 3.3
Oats	per cent.. 33
Barley	per cent.. 16

For Dakota I have details for 1885.

Using these yearly percentages of increase where given, and where not given using the yearly percentages of increase for 10 years, as obtained from Census Reports of 1870 and 1880, I get the following table, whose figures are undoubtedly much below actuality.

Products Missouri River Valley, 1885.

State or Territory.	Population.	Corn.	Oats.	Rye.	Wheat.	Barley.
		Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Missouri	700,000	72,000,000	10,200,000	200,000	13,000,000	100,000
Kansas	135,600	8,640,000	1,415,000	100,000	2,892,000	60,000
Nebraska	200,000	34,156,000	3,852,000	794,000	2,500,000	557,000
Iowa	168,000	178,500,000	2,200,000	861,000	5,362,000	600,000
Montana	21,500	7,500	830,000	600	420,000	[illegible]
Dakota	72,000	3,800,000	2,250,000	26,000	1,109,000	121,000
Total	1,297,100	297,103,500	20,747,000	1,981,600	25,283,000	1,531,000

The details of 1885 for Nebraska were received after calculations for the above table had been made and were found to be less than actuality, except for corn. Hence I believe, the figures of the above table are not far from the truth.

UPPER RIVER.

The principal home port is Bismarck, Dak., where a railroad first crossed the upper river. As other railroads have pushed westward minor ports have grown up. But there are, and always will be, many "landings" and settlements dependent entirely on the river as a highway; and even from early years the trade of the upper river has been lucrative in spite of its difficulties.

The up-stream cargo is, as usual, general merchandise, and the down-stream hides, wool, furs, ore, and, especially of late years, grain.

The river is navigable to Benton from about May to the middle of August, and from then to the middle of October, the water being too low for boats above Cow Island, freights are landed there and hauled at a rate of 2 to 2½ cents per pound to their destination.

For the year 1867, Major Howell gives quite a comprehensive report, hereto appended and marked I.

From 1870 to 1877, it appears, after considerable investigation, with meager results, that the river trade increased 50 per cent., owing to improvement works.

During 1877, 25 steamers arrived at Fort Benton, landing 5,283 tons of freight and 1,500 passengers. These boats took down river 3,200 tons of freight and 500 passengers. The total value of the commerce of the river for that season was very nearly $3,500,000.

In 1878 and 1879, 46 steamers arrived at Benton, being nearly 100 per cent. more than in 1877. The freight brought up was 8,764 tons, between 40 and 50 per cent. more than in 1877. The wool shipped down was 350 tons, more than 50 per cent. increase over 1877. Many cattle, too, were shipped down.

In 1880–'81, the amount of freight, exclusive of Government freight, carried into Montana by the river was 8,456 tons; the total was 14,654 tons. The amount of wool shipped down was 300 tons.

In 1881–'82, from 20 to 30 steamboats plied on the Missouri, with headquarters at Bismarck, and making from six to seven trips apiece. The business of 1881 was in excess of that of any previous year. Twenty-one boats were running, the largest, the Dacotah, having a freight capacity of 1,400 tons, and the smallest a capacity of 250 tons. These boats carried into Montana 17,380 tons of freight, valued at $5,214,000. They also transported 1,300 white passengers, 2,400 Indians, 2,400 head of horses, cattle, and sheep.

In 1882–'83, the number of steamboat arrivals and departures at Bismarck was 86 each; at Benton, 40 each. Total shipment of freight from Bismarck was 16,097 tons,

valued at $4,829,000. Three thousand five hundred other passengers and 1,200 troops were transported. Total exports from Benton, 2,000 tons, valued at $613,000.

During 1883-'84, there was transported on the upper river 11,797 tons of freight and an unknown number of passengers.

During 1885, the carrying on the upper river above Bismarck was done mainly by the steamers Benton, Batchelor, Helena, and Rosebud. Fifteen round trips were made during the season, with total cargoes of 18,000 tons up-stream and 9,000 tons down-stream; or a grand total of 27,000 tons moved.

Mr. Justus Bragg, the mayor of Bismarck, writes that the river trade from Pierre, Dak., to Fort Benton is rapidly increasing, especially in shipments of wheat and oats, and that above Bismarck several thousand sacks of these grains were left on the bank when navigation closed. The wool shipments are also increasing rapidly.

The steamer General Terry also ran during 1885, but mainly below Bismarck. Chamberlain, Dak., a railroad terminus, is the principal port below Bismarck in the upper river, and between these two points about 15,000 tons were moved during 1885, together with about 500 passengers. This makes the grand total of freight moved on the Upper Missouri, during 1885, 42,000 tons.

Mr. T. C. Power, of Power Bros., owners of the Bismarck and Fort Benton steamers, says the freight carried in 1885 was 50 per cent. greater than that of 1884.

Mr. J. C. McVay, of Yankton, Dak., writes that the General Terry, General Tompkins, and Milwaukee ran during 1885 between Bismarck and Sioux City. The Terry made twenty round trips, averaging 30 passengers each, and handled between 12,000 and 15,000 tons during the season. The General Tompkins handled 7,000 tons of freight.

These steamers have handled all the Government freight for Forts Randall, Sully, Bennett, Meade, and Gates, and for the Indian agencies at Standing Rock, Cheyenne, and other places.

There are thirty or forty towns springing up between Sioux City and Bismarck, and where one boat did the business two years ago it requires 3 boats now.

Rates of insurance on hulls—

	Per cent.
1884	13
1885	15

During a visit made by me to Bismarck in May, 1886, I talked with pilots, the steamboat company's agents, townspeople, and the depot quartermaster stationed there. The last assured me that 300 tons per month for 5 boats for six months in the year (total 9,000 tons), was a liberal estimate for the trade above Bismarck—that very little bullion and valuable furs were brought down. This reduces the freight on this line to the level in value of the lower-river freight and disposes of the claim of the upper-river trade to greater money value. The evidence of the quartermaster was borne out by the other information.

In this connection I give a compilation of the river trade at Bismarck for the present year to date, which was collected by our assistant engineer in charge of the steamer Missouri, and which I believe to be almost exact.

Powers Line. Above Bismarck to Benton (816 *miles*). 1886.

Name.	Up.			Down.		
	Date of departure.	Tons.	Remarks.	Date of arrival.	Tons.	Remarks.
Rosebud	Apr. 20	275	Principally to Fort Benton.	May 22	225	Hides, wheat (75 from Benton, 150 from Grinnell's).
Helena	May 5	350	Fort Benton	May 29	*180	Wool and hides, Benton; grain, way points.
Batchelor	May 8	250	Through to Benton	May 30	†150	Benton and way points.
Rosebud	May 26	275	Principally for Benton.	June 11	100	18 bales of wool; took *all* freight offered.
Benton	May 31	425	Mostly way freight.			
Total		1,575			655	

*Also 30 horses and 15 passengers. †Also 12 passengers.

All carried a general assortment—corn for Fort Buford, barbed wire, groceries, farm-machinery, oil, bottled beer, and liquors. Returning, wheat from Fort Buford and Grinnell's, dried hides, sheep pelts, empty beer cases, deer and antelope skins, and wool.

Mr. Warren's letter of June 12 says: "Captain Todd, of Rosebud, reported having taken all freight offered. The Rosebud goes out of commission for a time. Not enough freight here to load the Judith" (old N. P. Transfer No. 2).

Evans Line. Below Bismarck to Chamberlain, Dak. (350 *miles*). 1886.

Name.	Down.			Up.		
	Date of departure.	Tons.	Remarks.	Date of arrival.	Tons.	Remarks.
Terry	Apr. 17	125	Standing Rock Agency, 70 miles.	Apr. 20	100	
Do	Apr. 21	150	Chamberlain and way.	May 4	100	
Do	May 5	125	Way and Pierre, 252 miles.	May 13	100	
Tompkins*				May 7	125	From Pierre and way.
Do	May 13	100	Coal Harbor, 800 miles above Bismarck, for wheat.	May 9	100	
Terry	May 15	125	Pierre and way			
Do	May 26	150	Lumber and shingles (80 for Standing Rock; 70 for Pierre and way).	May 24	80	
Do	June 11	80	Pierre and way	June 10	75	Miscellaneous freight.
Total		855			680	

* Tompkins "retired" May 13.

Freights down: Agency and town supplies, lumber and shingles, bottled beer. Up, wheat, hides, "empties," a few passengers.

The steamboats on the Upper Missouri are not in direct competition with railroads, as on the lower river, and perhaps never will be. This relieves the rivermen in that section from the necessity for silence which is felt below, but their statements are to be taken with caution unless proved from other sources.

In my endeavors to get exact data in regard to the 1885 trade, at Bismarck, I was met by the most extravagant and indefinite accounts.

Such facts as I have been able to gather by no means bear out the boast of the upper-river men, that their trade far surpasses, in money value, that of the lower river—the evidence seems to be very much the other way.

As regards the Yellowstone River its trade was considerable, as will be seen from the appendices, until the Northern Pacific Railroad was completed to Glendive in 1881, at which time the trade dwindled to almost nothing. Its chances for revival are slim, as Glendive is not over 100 miles from the mouth of the river.

There will be found appended the annual reports of commercial statistics for the Upper Missouri and Yellowstone rivers, published in the Reports of the Chief of Engineers (Appendices II, III, IV, V, VI, and VII).

ADVANTAGES OF IMPROVEMENT.

As before stated, steamboat agents proved very unwilling to communicate in regard to their business, and it is my belief that for the lower river, the figures already given can be safely increased 25 per cent.

It may seem surprising, that passing, as it does, the granary States of the world, so little grain is transported by the Missouri River. Undoubtedly this is mostly due to the railroads, who are apparently the bugbears of the steamboat agents. It is easy to see how, by discriminations and by differences between local and through tariffs—added to the fact that the country along a railroad is to a great extent vassal to it—railroads can, by their combination, ruin the trade of a single highway.

But it is not in these ways only that railroads have succeeded in practically suppressing Missouri River traffic. The bridges are the obstacles to river trade.

The advantage of a water route lies in the huge cargoes of barges that can be guided by one tow-boat. In a tortuous and swift stream, like the Missouri, a large tow is difficult to handle at all times, but when the dangers are increased by a number of bridge piers not only blocking the highway but giving rise to currents and eddies which not infrequently affect the river channel, the difficulties become so great

that there are, at present, no barges run on the Missouri River. Insurance is too high. Yet, with the proposed improved channel, of 12 feet, barges could largely be used in spite of the bridges.

A curious feature of bridge bills is, that where they are built high they invariably have (so called) long spans, but where there is a draw pier, which is a far greater obstacle than an ordinary high bridge pier, the channel span is no longer than in the other case and has besides, directly in the middle, a formidable obstruction.

The other side of this case is illustrated by the following extract from a letter of Mr. S. W. Cobb, president of the Saint Louis Merchants' Exchange, and taken from the Republican of May 12, 1886, page 7:

* * * * * * *

"The arrivals and departures of freight and passenger steamers have decreased, and will continue to do so. The fact is due to two causes: The steamers of the past were comparatively smaller. The tonnage or carrying capacity of the steamers of to-day is much greater than that of the steamboats of former years. In addition to this, the building of railways along the rivers has taken the high-classed freight business from the steamboats, and to-day the business of the steamboats is confined to the cheapest class of freight. Wholesale merchants of Saint Louis, with customers along the Missouri River, advise that the retail merchants doing business at river towns which are not reached via rail generally order their goods by boat, if boat is to leave the day or the day following receipt of order; otherwise ship via rail. They are willing to pay the higher rates of freight and cost of transporting by wagons from their nearest rail point rather than to wait two or three days for a boat."

* * * * * * *

"The arrivals and departures of steamers plying on the * * * Missouri River * * * during the past six years were—

1880	332
1881	250
1882	226
1883	185
1884	211
1885	152

"These figures are taken from the reports of our exchange, and are as near correct as statistics can be. There is but one conclusion to draw, and that is, that the steamboat business is becoming less profitable year by year."

* * * * * * *

"The Missouri River is practically unobstructed and its traffic has suffered most."

* * * * * * *

"In the abstract we are justified in the conclusion that the bridges have little to do in destroying river traffic. We ascribe its decay more to rail lines paralleling or tapping the river's territory.

* * * * * * *

"S. W. COBB,
"*President.*"

But when it is considered that water transportation between the Missouri Valley and Liverpool, for instance, is between 40 and 50 per cent. cheaper than via rail to New York, and that the river *can* be improved so as to be permanently passable for huge fleets, and that the saving in one year would more than pay for said improvements, it seems a pity that the money should not be forthcoming at once.

Table 13 shows the difference in rail and water rates referred to above, and the following extract is very pertinent. It is from a call issued for a convention at Kansas City, in November, 1885, to discuss and urge lower-river improvement. After citing the facts given on page 8, it goes on to say:

"In 1878 the river rate was 5½ cents per bushel for corn and 7½ cents for wheat, including insurance; railroad rate was 8 cents per bushel for corn and 13 cents for wheat. With adequate improvement experience seems to show that grain can be floated from Kansas City to New Orleans for 7 cents per bushel.

"Considering the whole Missouri Valley, and adding 3 cents per bushel for excess of distance to New Orleans from foreign ports over Atlantic coast ports it is believed that 12 cents per bushel will make grain available for transportation from New Orleans at the same rates as from Atlantic ports.

"The rail rates for years past from Missouri Valley points to the Atlantic have not been less than 21 cents on wheat and 16 cents on corn, a difference of 9 and 4 cents in favor of the river route.

"Taking the figures given on page 8, from census of 1880, we have a saving to the producers of over $22,000,000 by the use of the river route, and this is for one year

only. This amount is more than twenty times the amount asked for by the Missouri River Commission for one year. Supposing a very bad year reduces the crops 66 per cent., there is still a saving of seven times what the Commission ask for the ensuing season."

In order to obtain a depth of 12 feet at low water wide enough for navigation, a result that can be regarded as perfectly practicable, suppose it were necessary to spend as much as $50,000 per mile, which recent experience almost conclusively shows to be a liberal estimate, the cost of obtaining this channel as far up as Kansas City (386 miles) would be less than $20,000,000, an amount, as before shown, saved to the producers of the valley in one year.

To carry the same improvement to Sioux City (803 miles) would cost only about $40,000,000 saved to the producers in two years.

Taking the low figure of $20,000 per mile as sufficient to build a single-track railroad, we have for two and a half times as much money a highway free to all, and with six hundred times more carrying capacity.

On the other side I get the following from credible authority:

For several years past the commerce of New Orleans has been decreasing.

Grain is nowadays largely carried as ballast, and vessels are not seeking ports merely to carry away grain. The Atlantic ports have this advantage over the Gulf ports, that their imports bring vessels there for other purposes which can and do carry grain back *as ballast and for nothing*.

Consequently, if New Orleans loses its prominence as an importing center, this loss will very materially influence the route of the products of the Mississippi and Missouri River valleys to a market, even supposing both rivers navigable at low water.

Captain Patterson informs me that the lowest available depth in the Missouri River during 1885 was at the Osage, about 3.25 feet.

At Miami, when our fleet came out in November, two steamers rubbed, but one got 5 feet.

At Marthasville there was about 4 feet, and even at the best during the season only about 6 feet.

The information herewith handed to the Commission has been obtained from sources too numerous to mention. But to those who have assisted me, should this reach their eyes, I extend my thanks.

Very respectfully, your obedient servant,

THEO. A. BINGHAM,
First Lieutenant of Engineers,
Secretary Missouri River Commission.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

TABLES.

TABLE 1.—*List of steamers plying on Missouri River, in the district of Saint Louis, giving name of vessel, where and when built, date of last inspection, with certain other detailed information, as indicated below.*

Name.	Where built.	Year.	Date of last inspection.	Length.		Breadth.		Depth.	
				Ft.	In.	Ft.	In.	Ft.	In.
Aggie	Manchester, Ohio	1875	Mar. 24, 1885	92	4	20	4	3	0
A. W. Ewing	Osage City, Mo	1878	Aug. 10, 1885	...	...	...	...	...	...
Anna	Grafton, Ill	1872	Apr. 14, 1885	101	2	28	2	4	4
C. C. Carroll	Pittsburgh, Pa	1875	Nov. 14, 1884	222	0	36	0	5	5
Dan. B. Hurlbut	Warsaw, Mo	1881	Mar. 16, 1885	62	6	11	0	2	4
Dora	Boerger's Landing, Mo	1882	Nov. 30, 1885	90	9	20	0	3	6
Dakotah	Pittsburgh, Pa	1879	June 18, 1885	252	0	48	8	5	5
David R. Powell	Cincinnati, Ohio	1881	Apr. 18, 1885	258	0	38	0	7	2
Emma	Linn Creek, Mo	1876	Mar. 16, 1885	120	2	24	0	2	9
Frederick	Tuscumbia, Mo	1883	Mar. 8, 1885	94	4	14	3	3	0
Fawn	Hermann, Mo	1880	Aug. 10, 1885	91	9	19	1	3	4
General Meade	Pittsburgh, Pa	1875	Aug. 7, 1885	192	0	30	0	4	3
John L. Ferguson	Grafton, Ill	1876	Nov. 24, 1884	111	6	26	6	3	6
May Bryan	Jeffersonville, Ind	1875	Nov. 6, 1885	115	0	28	0	4	5
Royal	Hermann, Mo	1884	Nov. 6, 1885	86	6	24	0	3	0
Statie Fisher	Jeffersonville, Ind	1875	Mar. 24, 1885	122	0	38	8	4	0
Troy	Hermann, Mo	1881	Aug. 18, 1884	...	...	...	...	...	...
Vienna*	Plattsmouth, Nebr	1879	Mar. 25, 1885	80	8	24	0	2	8

TABLE 1.—*List of vessels plying on Missouri River, &c.*—Continued.

Name.	Capacity under tonnage deck.	Capacity between decks.	Total tonnage.	State-rooms.	Berths.	Passengers. Permitted to carry.	Passengers. First cabin.	Passengers. Steerage or deck.	Engines (high pressure). Number.	Engines (high pressure). Diameter of cylinder.	Engines (high pressure). Length of stroke of piston.
	Tons.	*Tons.*	*Tons.*	*No.*	*No.*	*No.*	*No.*	*No.*		*In.*	*Ft.*
Aggie	66.73	21.84	88.57	4	8	28	8	20	2	12	3½
A. W. Ewing			4.00			20		20	2	6	8¾
Anna	78.67		78.67						1	6	8¾
C. C. Carroll	361.73	210.02	571.75	26	45	70	40	30	2	16	5
Dan. B. Hurlbut	12.93		12.92						2	6	1⅞
Dora	54.20	26.88	81.08	1	4	20	8	12	2	7	2½
Dakotah	574.90	382.08	956.98	25	50	120	71	55	2	18	7
David R. Powell	586.05	302.69	888.74	30	58	108	58	50	2	22	7
Emma †	76.52		76.52						2	8	2
Frederick	34.49	48.02	82.51		10	15		15	2	7	2½
Fawn	49.73	23.27	73.00	3		50	20	30	2	8	2
General Meade	171.46		171.46	14	30	45	27	18	2	12½	4½
John L. Ferguson ‡	79.81		79.81						2	11	4
May Bryan	97.40		97.40			50		50	1	16	5
Royal	44.82		44.82			20		20	2	8	2½
Statie Fisher ‡	106.52		106.52						1	16½	5
Troy			4.00			8		8	1	4	½
Vienna	47.60	25.57	73.17			20		20	2	8	1½

Name.	Boilers. Number.	Boilers. Length.	Boilers. Diameter.	Boilers. Kind of material.	Boilers. When built.	Boilers. Steam-pressure.	Licensed to run on—
		Ft.	*Ft.*			*Lbs.*	
Aggie	2	16	3	Iron	1875	138	Mississippi and tributaries.
A. W. Ewing	1	3	3½	Steel	1885	125	Do.
Anna	1	8	2	Steel	1877	100	Do.
C. C. Carroll §	3	26	3½	Iron	1875	130	Do.
Dan. B. Hurlbut	1	11¾	3½	Steel	1885	110	From mouth of Osage River to head of navigation.
Dora	1	18	3½	Steel	1882	120	Mississippi and tributaries.
Dakotah §	4	26	3½	Iron	1879	140	Do.
David R. Powell	4	24	3¾	Steel	1885	165	Do.
Emma	1	18	3	Iron	1876	120	From mouth of Osage River to head of navigation.
Frederick	1	14	3	Iron	1883	150	Mississippi and tributaries.
Fawn	1	14	3½	Iron	1877	110	Do.
General Meade	2	20	3	Iron	1875	137	Do.
John L. Ferguson	1	16	3½	Iron	1864	100	Missouri River between Saint Charles and opposite shore.
May Bryan	1	22	3¾	Iron	1875	113	Missouri River between Hermann and Saint Charles.
Royal	1	12	3	Steel	1884	125	Mississippi and tributaries.
Statie Fisher	1	23	3½	Steel	1875	130	Between Jefferson City and Cedar City.
Troy	1	3½	2½	Iron	1882	125	Mississippi and tributaries.
Vienna	1	12	3½	Iron	1879	110	Do.

* Rebuilt at Hermann, Mo., 1882.
† Freight boat.
‡ Ferry-boat.
§ Draught (light) 2 feet 2 inches to 3 feet.

TABLE 2.—*List of steamers plying on Missouri River, in the district of Upper Missouri giving name of vessel, where and when built, cost, with certain other detailed information, as indicated below.*

Name.	Where built.	Year.	Cost.	Home port.
Benton			$25,000	
Helena			22,500	
Rosebud			20,000	
Batchelor	Pittsburgh, Pa.	1878	18,500	Bismarck, Dak.
General Terry	do	1878	16,000	Do.
U. S. Joseph			19,000	
General Tompkins				
Denver	Pittsburgh, Pa.	1871		Saint Paul, Minn.
Dr. Burleigh	Wyandotte, Kan.	1866		Yankton, Dak.
Eclipse	Pittsburgh, Pa.	1878		Saint Paul, Minn.
Far West	do	1875		Bismarck, Dak.
General Custer	Alleghany City, Pa.	1877		Do.
Ida Stockdale				Do.
Northern Pacific	Mound City, Ill.	1879		Do.
Northern Pacific, No. 2*	do	1881		Do.
Nellie Peck	Pittsburgh, Pa.	1871		Do.
Union	Brunswick, Mo.	1861		Do.
Undine	Wellsville, Ohio			Do.
Yellowstone	Jeffersonville, Ind.	1876		Do.

Name.	Tonnage.				Engines.			Draught.		Will carry loaded.
	Total.	On three feet draught.	On two feet draught.	To the inch.	Diameter of cylinder.	Length of stroke of piston.	Horse-power.	Light.	Loaded.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*In.*	*Ft.*		*Ft.*	*Ft.*	*Tons.*
Benton	394.08	181.90	55	14.00	16	5	325.42	(†)	†3 [illegible]/12	400
Helena	352.31	205.50	70	13.50	18	4	244.42	(†)	†3 [illegible]/12	275
Rosebud	286.49	182.10	75	11.90	13	4	283.48	(†)	†3 [illegible]/12	250
Batchelor	313.00	195.60	90	11.90	13	5	244.42	(†)	†3 [illegible]/12	275
General Terry	323.15	186.00	75	11.50	13	4	239.98	$1\frac{1}{2}$	†4 [illegible]/12	
U. S. Joseph	300.51	180.70	70	12.30			325.42			
General Tompkins	300.00				15	4		$1\frac{1}{2}$	†4	
Denver	180.00									
Dr. Burleigh	57.05									
Eclipse	295.98				$13\frac{1}{2}$	4		(†)	†3 [illegible]/12	250
Far West	397.81									
General Custer	241.34									
Ida Stockdale	377.39									
Northern Pacific	328.82									
Northern Pacific, No. 2*	253.94									
Nellie Peck	280.77									
Union	72.18									
Undine	76.98									
Yellowstone	167.27									

*Now (June, 1886) the Judith.

† Average.

TABLE 3.—*List of steamers and barges plying on Missouri River, in the district of ——, giving name of vessel, with certain other detailed information, as indicated below.*

Name.	Kind of vessel.	Length.	Breadth.	Engines.		Boilers.		
				Diameter of cylinder.	Length of stroke of piston.	Length.	Diameter.	Kind of material.
		Feet.	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	
Senator	Steamer							
Cora Ryan	...do							
Andrew S. Bennett	...do							
John F. Lincoln	...do							
President								
Queen No. 2								
Minnona								
Vice-President								
Capitola								
Butt								
J. F. Joy								
Belle of Brownville		110	32	16	4½	18	4	Steel.
White Cloud								
Willie Cade								
Annie Cade								
Minnie Thomas								
Mattie Lee								
Annie Lewis								
Birdie Brent								
Carrie								
Rob Roy								
Plow-Boy								

TABLE 4.—*Population and products of counties in the State of Missouri along the Missouri River.*

Counties.	Population.		Buckwheat.		Indian corn.		Oats.	
	1870.	1880.	1884.	1880.	1884.	1880.	1884.	1880.
			Bush.	*Bush.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Andrew	15,137	16,318		184		2,723,745		254,728
Atchison	8,440	14,556		261		4,977,476		176,833
Boone	20,765	25,422		43		2,537,859		291,453
Buchanan	35,109	49,792		65		2,289,204		188,642
Calloway	19,202	23,670		61		2,219,588		438,992
Carroll	17,446	23,274		828		5,290,581		455,826
Chariton	19,136	25,224		1,518		3,565,473		298,011
Clay	15,564	15,572				2,204,376		104,311
Cole	10,292	15,515		130		586,157		110,298
Cooper	20,692	21,596		313		2,389,965		253,289
Franklin	30,098	26,534		76		1,342,997		262,875
Gasconade	10,093	11,153		55		530,732		171,163
Holt	11,652	15,509				3,308,326		174,108
Howard	17,233	18,428		1,039		1,770,520		161,155
Jackson	55,041	82,325		88		3,760,259		178,435
La Fayette	22,623	25,710		93		3,812,887		244,992
Moniteau	11,375	14,346		36		1,355,512		182,098
Montgomery	10,405	16,249		365		1,927,103		551,506
Osage	10,793	11,824		117		598,479		94,530
Platte	17,352	17,366		750		2,038,870		128,410
Ray	18,700	20,190		40		3,490,332		224,116
Saint Charles	21,304	23,065				1,614,960		249,554
Saint Louis*				106		1,893,425		177,773
Saline	21,672	29,911		86		4,836,829		344,695
Warren	9,673	10,806		105		819,500		270,985
Total	249,797	554,355		6,309		61,685,155		5,991,278
Total State	1,721,295	2,168,380	90,937	57,640	190,008,046	202,414,418	31,857,700	20,670,958
Percentage	45 p. ct.	26 p. ct.		11 p. ct.		30 per ct.		29 p. ct.

TABLE 4.—*Population and products of counties in the State of Missouri, &c.*—Continued.

Counties.	Rye.		Wheat.		Barley.		Value of orchard products.
	1884.	1880.	1884.	1880.	1884.	1880.	1880.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	
Andrew		8, 487		291, 717		106	$55, 400
Atchison		22, 053		329, 810		62, 580	21, 381
Boone		12, 431		337, 021			28, 075
Buchanan		8, 311		443, 178		513	65, 922
Calloway		4, 738		234, 236			22, 001
Carroll		12, 926		309, 628			19, 330
Chariton		11, 814		229, 061		435	25, 330
Clay		7, 888		257, 867			20, 550
Cole		2, 379		288, 193		232	6, 193
Cooper		4, 225		516, 138		50	16, 636
Franklin		1, 012		796, 726		1, 223	17, 961
Gasconade		387		343, 224		1, 642	2, 584
Holt		19, 260		207, 907		8, 868	30, 921
Howard		12, 018		308, 034			21, 434
Jackson		4, 159		449, 335		150	36, 118
La Fayette		2, 781		857, 668		1, 349	41, 614
Moniteau		908		222, 339		93	9, 161
Montgomery		8, 361		193, 085		65	23, 001
Osage		533		836, 879		103	1, 914
Platte		4, 544		600, 654		40	51, 854
Ray		6, 883		181, 646			25, 079
Saint Charles		2, 084		1, 124, 518		5, 910	41, 608
Saint Louis*		6, 643		908, 838		2, 678	97, 342
Saline		7, 716		838, 105			23, 045
Warren		760		306, 925		1, 362	12, 865
Total		163, 330		11, 023, 652		87, 333	730, 470
Total State	545, 000	535, 426	29, 701, 687	24, 966, 627	140, 120	123, 031	1, 812, 837
Percentage		31 per ct.		45 per ct.		70 per ct.	40 per ct.

Counties.	Hay.		Irish potatoes.		Sweet potatoes.		Tobacco.		Cotton.
	1870.	1880.	1884.	1880.	1870.	1880.	1884.	1880.	1880.
	Tons.	*Tons.*	*Bushels.*	*Bushels.*	*Bush.*	*Bush.*	*Pounds.*	*Pounds.*	*Bales.*
Andrew		17, 449		58, 068		2, 034		12, 257	
Atchison		16, 400		36, 235		1, 141		12, 608	
Boone		11, 063		40, 493		8, 223		40, 956	
Buchanan		7, 551		94, 410		14, 279		12, 035	
Calloway		12, 220		30, 922		2, 561		570, 231	
Carroll		15, 580		70, 418		3, 287		639, 325	
Chariton		18, 551		65, 403		1, 245		4, 384, 924	
Clay		7, 257		42, 702		4, 401		1, 243	
Cole		4, 035		30, 036		1, 566		5, 430	
Cooper		6, 007		38, 226		2, 696		21, 252	
Franklin		4, 997		91, 212		2, 158		94, 154	
Gasconade		3, 303		38, 398		651		8, 024	
Holt		11, 827		87, 964		1, 543		18, 337	
Howard		8, 440		21, 885		2, 839		604, 794	
Jackson		18, 182		77, 939		22, 893		41, 986	
La Fayette		11, 057		54, 655		7, 218		16, 060	
Moniteau		4, 962		23, 435		1, 244		7, 310	
Montgomery		7, 635		85, 440		1, 152		181, 761	
Osage		3, 330		27, 474		600		52, 010	5
Platte		7, 481		45, 571		6, 000		6, 260	
Ray		15, 646		36, 796		4, 241		701, 052	
Saint Charles		7, 155		67, 241		1, 462		52, 453	
Saint Louis*		14, 603		308, 809		78, 725		1, 288	
Saline		13, 800		40, 919		8, 147		540, 175	
Warren		2, 767		27, 400		849		86, 672	
Total		251, 358		1, 442, 440		176, 215		8, 112, 186	5
Total State	615, 611	1, 077, 458	7, 020, 775	4, 169, 694	241, 253	431, 484	12, 867, 740	12, 015, 657	20, 318
Percentage		23 p. ct.		34 p. ct.		40 p. ct.		68 p. ct.	.02 p. ct.

* City and county separated in 1876.

TABLE 5.—*Population and product of counties in the State of Kansas along the Missouri River.*

Counties.	Population.			Barley.		
	1880.	1883.	1884.	1880.	1883.	1884.
				Bushels.	*Bushels.*	*Bushels.*
Atchison	26,668	28,853	20,263	4,280	4,108	10,950
Doniphan	14,257	12,971	13,216	37,526	62,910	40,488
Leavenworth	32,355	32,404	35,381	1,747	2,325	....
Wyandotte	19,143	25,100	26,775	300	....	....
Total	92,423	99,334	104,634	43,853	60,343	51,438
Total State	996,096	1,028,729	1,135,614	300,273	380,960	556,226
Percentage	9 per ct.	10 per ct.	9 per ct.	15 per ct.	18 per ct.	9 per ct.

Counties.	Buckwheat.			Corn.		
	1880.	1883.	1884.	1880.	1883.	1884.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Atchison	279	63	....	2,129,689	2,776,897	2,091,241
Doniphan	58	....	20	2,475,986	3,238,800	2,913,408
Leavenworth	117	....	....	1,785,976	2,087,865	1,973,700
Wyandotte	70	5,805	264	620,640	695,353	654,885
Total	524	5,868	284	7,012,291	8,798,915	8,233,284
Total State	24,421	19,575	12,980	105,729,325	182,084,526	190,870,686
Percentage	2 per ct.	30 per ct.	2 per ct.	7 per ct.	5 per ct.	4 per ct.

Counties.	Oats.			Rye.		
	1880.	1883.	1884.	1880.	1883.	1884.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Atchison	182,372	600,600	291,525	6,868	65,642	34,200
Doniphan	209,185	468,090	340,500	10,536	37,425	12,801
Leavenworth	188,816	636,795	476,318	1,604	15,740	7,404
Wyandotte	57,493	102,320	113,960	1,500	2,599	1,196
Total	637,866	1,807,865	1,231,323	20,508	121,406	55,601
Total State	8,180,385	30,967,864	20,087,204	413,181	5,084,391	6,235,575
Percentage	8 per ct.	6 per ct.	6 per ct.	5 per ct.	2 per ct.	$\frac{9}{10}$ per ct.

Counties.	Wheat.			Hay.		
	1880.	1883.	1884.	1880.	1883.	1884.
	Bushels.	*Bushels.*	*Bushels.*	*Tons.*	*Tons.*	*Tons.*
Atchison	362,078	339,280	559,756	24,924	26,873	33,171
Doniphan	518,140	680,931	838,981	7,246	28,284	37,067
Leavenworth	418,211	536,686	851,532	19,202	43,709	59,545
Wyandotte	178,599	240,614	266,826	2,573	19,193	18,294
Total	1,477,028	1,793,511	2,517,095	53,945	118,059	148,077
Total State	17,324,141	30,024,936	48,050,431	1,589,897	447,367	645,060
Percentage	9 per ct.	6 per ct.	5 per ct.	3 per ct.	26 per ct.	23 per ct.

Counties.	Irish potatoes.			Sweet potatoes.		
	1880.	1883.	1884.	1880.	1883.	1884.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Atchison	91,116	177,440	205,375	2,654	4,230	2,430
Doniphan	92,204	159,200	145,700	1,008	630	1,575
Leavenworth	98,393	189,520	153,375	12,949	6,840	3,800
Wyandotte	82,919	353,440	257,100	20,011	56,970	11,880
Total	364,632	879,600	761,550	36,622	68,670	19,685
Total State	2,894,198	6,443,600	7,558,354	195,225	368,820	302,950
Percentage	13 per ct.	14 per ct.	10 per ct.	19 per ct.	19 per ct.	6 per ct.

TABLE 5.—*Population and product of counties in the State of Kansas, &c.*—Continued.

Counties.	Tobacco.			Flax.	
	1880.	1883.	1884.	1883.	1884.
	Pounds.	*Pounds.*	*Pounds.*	*Bushels.*	*Bushels.*
Atchison	6,088	40,000	850	57,537	40,[illegible]
Doniphan	8,335	1,600	850	600	[illegible]
Leavenworth	3,785	1,600	....	6,230	6,[illegible]
Wyandotte	5,150	....	1,700	80	72
Total	23,358	43,200	3,400	64,447	47,4[illegible]
Total State	191,669	778,400	173,400	1,150,995	1,[illegible]
Per centage	12 per ct.	6 per ct.	2 per ct.	6 per ct.	5 per ct.

TABLE 6.—*Population and product of counties in the State of Nebraska along the Missouri River.*

Counties.	Population.		Barley.		Buckwheat.	Indian corn.	
	1870.	1880.	1885.	1880.	1880.	1885.	1880.
			Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Blackbird	31	100	....	....	....	....	....
Burt	2,847	6,937	11,480	2,068	207	2,884,190	1,655,[illegible]
Cass	8,151	10,683	157,450	108,631	708	6,201,072	4,312,[illegible]
Cedar	1,032	2,899	55,360	8,605	297	830,192	217,[illegible]
Dakota	2,040	8,213	10,400	1,357	....	1,026,126	[illegible]
Dixon	1,345	4,177	21,840	3,197	162	1,020,015	[illegible]
Douglas	19,982	37,645	24,115	29,809	687	1,719,405	1,[illegible]
Knox	261	3,666	27,500	5,620	....	756,096	106,[illegible]
Nemaha	7,593	10,451	32,480	35,412	525	5,220,480	2,942,[illegible]
Otoe	12,345	15,727	151,823	113,980	238	4,783,115	[illegible]
Richardson	9,780	15,031	42,625	50,737	944	4,971,853	[illegible]
Sarpy	2,913	4,481	13,680	21,796	253	1,826,240	1,[illegible]
Washington	4,452	8,631	8,480	13,682	1,294	2,897,017	2,[illegible]
Total	72,772	129,650	557,173	395,794	5,874	34,155,800	23,[illegible]
Total State	122,993	452,402	4,643,822	1,744,686	17,562	153,506,370	65,[illegible]
Percentage	59 per ct.	29 per ct.	12 per ct.	23 per ct.	31 per ct.	22 per ct.	35 per ct.

Counties.	Oats.		Rye.		Wheat.	
	1885.	1880.	1885.	1880.	1885.	1880.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Blackbird	....	....	....	....	....	....
Burt	286,742	175,356	2,860	6,314	249,551	[illegible]
Cass	450,697	228,877	74,880	17,759	410,125	394,[illegible]
Cedar	515,200	59,722	2,130	61	90,112	[illegible]
Dakota	136,970	35,964	3,000	137	39,863	83,[illegible]
Dixon	260,480	30,706	5,080	1,094	76,927	34,[illegible]
Douglas	299,670	213,485	12,850	9,690	49,066	[illegible]
Knox	205,871	40,805	28,800	1,283	92,481	[illegible]
Nemaha	376,480	118,606	46,000	11,245	736,208	273,[illegible]
Otoe	388,426	197,394	38,394	14,000	210,436	248,[illegible]
Richardson	240,912	188,220	95,657	23,377	269,420	372,[illegible]
Sarpy	237,115	208,092	438,000	8,124	39,623	105,[illegible]
Washington	453,168	259,416	46,500	19,954	230,137	319,[illegible]
Total	3,851,740	1,757,243	794,211	107,838	2,493,949	2,209,[illegible]
Total State	24,973,203	6,555,875	3,770,390	424,348	19,690,802	13,847,[illegible]
Percentage	15 per ct.	27 per ct.	21 per ct.	25 per ct.	13 per ct.	16 per ct.

TABLE 6.—*Population and product of counties in the State of Nebraska, &c*—Continued.

Counties.	Value of orchard products.	Hay.	Irish potatoes.		Sweet potatoes.	Tobacco.
	1880.	1880.	1885.	1880.	1880.	1880.
		Tons.	*Bushels.*	*Bushels.*	*Bushels.*	*Pounds.*
Blackbird	....	....	....	....	....	....
Burt	$206	28,223	37,987	81,408	71	1,835
Cass	6,974	21,688	132,126	70,502	517	3,925
Cedar	20	19,163	42,790	23,747	....	380
Dakota	1,069	21,091	31,602	33,654	38	....
Dixon	25	21,100	38,813	27,563	....	300
Douglas	3,412	28,206	145,718	87,462	2,230	1,700
Knox	106	8,214	74,430	20,084	....	....
Nemaha	13,995	13,650	59,948	96,286	197	2,100
Otoe	15,529	23,299	124,867	81,642	420	10,005
Richardson	9,828	24,695	92,629	58,723	369	4,861
Sarpy	1,435	12,554	53,723	53,950	256	....
Washington	2,782	31,802	92,421	72,645	292	944
Total	54,901	258,685	927,054	608,666	4,390	26,110
Total State	72,244	785,433	4,531,241	2,150,898	13,628	57,979
Percentage	76 per ct.	34 per ct.	20 per ct.	28 per ct.	8 per ct.	45 per ct.

TABLE 7.—*Population and product of counties in Iowa and Montana along the Missouri River.*

STATE OF IOWA.

Counties.	Population.		Barley.	Buck-wheat.	Indian corn.	Oats.
	1870.	1880.	1880.	1880.	1880.	1880.
			Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Fremont	11,174	17,652	79,258	515	5,875,156	206,150
Harrison	8,931	16,649	3,910	803	4,308,991	156,725
Mills	8,718	14,137	32,156	528	4,192,319	230,171
Monona	3,654	9,055	3,305	207	2,320,332	101,907
Pottawattamie	16,893	39,850	73,325	1,391	7,350,176	370,788
Woodbury	6,172	14,996	3,115	250	1,458,939	41,286
Total river counties	55,542	112,339	195,159	3,694	25,560,913	1,107,087
Total State	1,194,020	1,624,615	4,022,588	166,895	275,014,247	50,610,591
Percentage	5 per cent.	7 per cent.	5 per cent.	2 per cent.	9 per cent.	2 per cent.

Counties.	Rye.	Wheat.	Value of orchard products.	Hay.	Irish potatoes.	Sweet potatoes.	Tobacco.
	1880.	1880.	1980.	1880.	1880.	1880.	1880.
	Bushels.	*Bushels.*		*Tons.*	*Bushels.*	*Bushels.*	*Pounds.*
Fremont	24,298	299,503	$17,265	20,633	62,845	1,008	6,609
Harrison	8,271	240 093	2,360	43,933	63,472	513	2,805
Mills	4,417	232,834	10,470	18,091	71,401	663	1,315
Monona	2,431	126,307	1,267	33,542	40,800	....	1,630
Pottawattamie	13,984	699,324	5,726	54,800	173,871	1,553	2,485
Woodbury	371	57,469	398	52,192	46,892	....	....
Total river counties	53,772	1,655,530	37,486	223,791	457,781	3,737	14,934
Total State	1,518,605	31,154,205	1,494,365	3,613,941	9,962,587	122,368	420,477
Percentage	4 p. ct.	5 p. ct.	3 p. ct.	6 p. ct.	5 p. ct.	3 p. ct.	4 p. ct.

TABLE 7.—*Population and product of counties in Iowa, &c.*—Continued.

TERRITORY OF MONTANA.

Counties.	Population.		Barley.		Buckwheat.		Indian corn.	
	1870.	1880.	1883.	1880.	1883.	1880.	1883.	1880.
			Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Choteau	517	3,058	1,405	244	....	....	1,005	....
Dawson	177	180	....	....	....	....	2,760	....
Gallatin	1,578	3,643	18,933	8,586	....	230	....	....
Jefferson	1,531	2,464	5,745	5,696	....	....	....	135
Lewis and Clark	5,040	6,521	6,271	5,958	20	107	925	1,210
Meagher	....	1,387	6,696	6,166	108	40	30	120
Total river counties	11,586	17,253	39,050	26,650	128	377	4,720	1,465
Total Territory	20,595	39,150	62,580	39,970	328	437	6,604	5,640
Percentage	56 p. ct.	44 p. ct.	63 p. ct.	67 p. ct.	39 p. ct.	86 p. ct.	71 p. ct.	26 p. ct.

Counties.	Oats.	Rye.	Wheat.		Hay.	Irish potatoes.	
	1883.	1883.	1883.	1880.	1880.	1883.	1880.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Tons.*	*Bushels.*	*Bushels.*
Choteau	205,160	170	7,805	2,401	1,682	19,762	9,922
Dawson	2,802	80	845	....	265	5,635	....
Gallatin	547,986	....	168,959	151,513	7,150	60,702	16,300
Jefferson	70,686	25	21,847	15,437	4,135	22,060	13,923
Lewis and Clark	79,960	240	52,782	30,531	9,119	94,755	41,999
Meagher	115,225	....	57,893	79,502	5,948	15,615	15,905
Total river counties	1,039,819	515	309,631	279,384	28,308	217,549	97,954
Total Territory	2,023,992	2,215	556,076	469,688	63,937	412,681	223,702
Percentage	51 p. ct.	23 p. ct.	55 p. ct.	59 p. ct.	44 p. ct.	53 p. ct.	43 p. ct.

TABLE 8.—*Population and product of counties in the Territory of Dakota along the Missouri River.*

Counties.	Population.		Barley.		Buckwheat.		Corn.	
	1880.	1885.	1880.	1885.	1880.	1885.	1880.	1885.
			Bushels.	*Bushels.*	*Bushels*	*Bushels*	*Bushels.*	*Bushels.*
Bonhomme	5,468	7,449	22,542	2,568	....	215	140,079	417,933
Bozeman	....	162	....	....	....	....	....	....
Brulé	238	7,524	....	9,987	....	702	3,370	170,836
Buffalo	63	864	....	80	....	20	430	12,133
Burleigh	3,246	5,354	....	5,439	55	60	9,334	18,630
Campbell	50	1,199	....	....	....	....	....	6,250
Charles Mix	407	4,022	900	3,595	....	948	9,695	324,963
Clay	5,001	6,201	5,008	32,684	223	437	375,837	908,743
Emmons	38	1,046	....	1,115	....	....	900	31,188
Hughes	208	5,268	....	2,147	....	1,256	1,160	57,016
Hyde	....	2,175	....	535	....	17	....	8,490
Mercer	....	254	....	256	....	....	....	4,593
Morton	200	5,873	....	4,534	....	292	....	50,223
Montraille	13	87	....	....	....	....	....	....
Potter	....	2,836	....	218	....	222	400	28,020
Stevens	247	55	....	....	....	....	....	....
Tully	296	3,238	....	774	....	40	....	27,479
Union	6,813	8,017	2,344	47,480	97	1,123	305,189	1,278,050
Walworth	46	1,412	....	160	....	105	1,850	10,010
Williams	15	36	....	....	....	....	....	....
Yankton	8,390	9,404	11,127	8,853	61	391	220,953	418,393
Total	30,799	71,921	41,921	120,425	436	5,827	1,069,197	3,793,546
Total for Territory	133,392	415,610	277,424	2,170,059	2,521	51,466	2,000,864	7,890,563
Percentage	23 p. ct.	17 p. ct.	15 p. ct.	6 p. ct.	18 p. ct.	11 p. ct.	53 p. ct.	49 p. ct.

TABLE 8.—*Population and product of counties in Dakota, &c.*—Continued.

Counties.	Oats.		Rye.		Wheat.		Value of orchard products.	
	1880.	1885.	1880.	1885.	1880.	1885.	1880.	1885.
	Bushels.	*Bushels.*	*Bushels*	*Bushels*	*Bushels.*	*Bushels.*		
onhomme	123,777	296,568	2,449	3,145	122,048	64,838	$120	$235
rulé		247,445		1,242		264,550		
uffalo	600	5,608			240	4,436		
urleigh	66,124	317,275				259,697		
ampbell		4,975				100		
harles Mix		10,685		961	66	52,396		60
lay	50,645	360,114	103	7,330	8,335	71,787	16	636
mmons	160	41,465				8,773		1,500
ughes		70,630		890		68,301		
yde		23,905		30		20,075		
ercer		10,800				3,197		
orton		99,252		430		20,681		
otter	600	21,237		55		6,300		
ully		36,740		484		36,646		
nion	80,672	405,097	1,626	9,199	13,023	131,779		256
alworth		11,766		163		3,906		
ankton	120,644	281,790	509	2,071	76,741	81,319	20	200
Total	393,222	2,245,352	4,768	26,022	220,453	1,108,711	156	2,887
Total for Territory	2,217,132	22,970,098	24,359	196,750	2,830,289	38,166,413	156	3,921
ercentage	18 p. ct.	10 p. ct.	20 p. ct.	13 p. ct.	8 p. ct.	8 p. ct.	100 p. ct.	74 p. ct.

Counties.	Hay.		Irish potatoes.		Wool.	Flax.
	1880.	1885.	1880.	1885.	1885.	1885.
	Tons.	*Tons.*	*Bushels.*	*Bushels.*	*Pounds.*	*Bushels.*
onhomme	17,433	19,520	21,106	23,529	32,915	161,465
ozeman	710		1,230			
rulé	453	9,814	2,225	30,710	4,548	22,393
uffalo	220	1,520	25	3,217	128	1,979
urleigh	4,120	6,952	57,635	84,440	9,723	20
ampbell	400	2,756		4,071	24	160
harles Mix	720	11,228	1,734	36,542	4,208	56,381
lay	35,812	62,347	44,450	46,335	9,971	26,471
mmons	380	8,568	1,725	19,230	16,260	112
ughes	150	7,718	42	29,764	267	12,792
yde		3,706		7,653	408	7,885
ercer		336		5,005		
orton		4,200		97,525	1,508	276
otter		4,157		10,342	791	1,667
tevens	425		5,185			
ully		5,912		15,565	2,080	5,810
nion	39,172	73,705	34,759	57,879	9,073	7,988
alworth	1,880	15,240	900	7,253	2,102	16
ankton	27,966	46,225	41,042	40,524	50,070	160,965
Total	129,341	284,000	212,057	519,174	144,135	466,380
Total for Territory	308,036	1,527,978	664,086	3,868,860	882,689	2,282,788
ercentage	42 p. ct.	19 p. ct.	32 p. ct.	13 p. ct.	16 p. ct.	20 p. ct.

TABLE 9.—*Missouri River trade.*

Years.	Received at Saint Louis.			Shipped from Saint Louis.		
	By river.	By rail.	Per cent. by river.	By river.	By rail.	Per cent. by river.
	Tons.	*Tons.*		*Tons.*	*Tons.*	
1874	44,830	3,165,093	....	20,390	1,290,676	....
1875	30,160	3,232,770	....	25,100	1,301,450	....
1876	50,345	3,431,220	....	19,360	1,659,950	....
1877	49,645	3,464,388	....	23,185	1,652,850	....
1878	56,040	3,785,307	....	22,465	1,880,559	....
1879	33,800	4,663,078	....	15,040	2,285,716	....
1880	59,025	6,096,524	....	16,415	2,755,680	....
1881	39,385	6,750,575	0.6	13,720	3,402,912	0.3
1882	34,900	6,900,622	0.5	11,980	3,749,160	0.3
1883	36,105	6,940,723	0.5	18,990	3,468,216	0.5
1884	29,860	6,440,787	0.5	15,285	3,611,419	0.4
1885	16,875	6,761,168	0.2	10,330	3,537,133	0.3

TABLE 10.—*Annual statement of trade and commerce of Saint Louis for* 1884 (*Merchants' Exchange*).

[Freight received at Saint Louis, Mo., in eleven years.]

Years.	Missouri Pacific Railroad (main line).	Wabash, Saint Louis and Pacific Railroad (westbranch).	Chicago, Alton and Saint Louis Railroad (Missouri division).	Missouri River.	Missouri River (rafts, &c., lumber, logs, and shingles).	Percentage by river.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Per cent.*
1875	229,447	238,866	....	30,160	....	[illegible]
1876	416,415	333,757	....	50,345	....	[illegible]
1877	354,513	318,768	....	49,645	....	[illegible]
1878	418,302	395,049	....	56,040	....	[illegible]
1879	425,840	366,797	143,313	33,800	....	[illegible]
1880	850,434	530,527	179,772	59,025	....	[illegible]
1881	907,467	447,449	154,248	39,385	....	[illegible]
1882	962,517	319,905	92,088	34,900	....	[illegible]
1883	1,092,591	429,494	135,688	33,770	2,835	[illegible]
1884	631,953	304,885	108,522	28,525	1,335	[illegible]
1885	548,779	392,202	83,020	16,875	2,195	[illegible]

[Freight shipped from Saint Louis, Mo., in eleven years.]

Years.	Missouri Pacific Railroad (main line).	Wabash, Saint Louis and Pacific Railroad (westbranch).	Chicago, Alton and Saint Louis Railroad (Missouri division).	Missouri River.	Missouri River (rafts, &c., lumber, logs, and shingles).	Percentage by river.
1875	151,890	116,674	....	25,100	....	[illegible]
1876	203,169	134,999	....	19,360	....	[illegible]
1877	202,966	137,394	....	23,185	....	[illegible]
1878	196,955	153,294	....	22,465	....	[illegible]
1879	272,250	197,219	45,596	15,040	....	[illegible]
1880	407,080	209,604	62,346	16,415	....	[illegible]
1881	709,814	254,902	72,393	13,720	....	[illegible]
1882	678,706	246,049	90,990	11,980	....	[illegible]
1883	563,398	[illegible],872	67,036	18,990	....	[illegible]
1884	830,481	217,409	81,827	15,285	....	[illegible]
1885	878,550	218,425	82,494	17,130	....	[illegible]

TABLE 11.—*Receipts at Saint Louis from the West and shipment to the West by rail and Missouri River in 1885.*

RECEIPTS.

Articles.	Designation.	By rail.				Missouri River.	Percentage by river.
		Chicago and Alton railroad (Missouri division).	Missouri Pacific railroad.	Wabash, Saint Louis and Pacific railroad (western division).	Total by rail.		
Provisions:							*P. ct.*
Pork	Barrels			300	390	540	138. 46
Hams	Pounds	648, 430	1, 631, 834	1, 870, 510	4, 150, 774	11, 115	0. 27
Meats	...do	1, 616, 130	8, 071, 518	12, 601, 373	22, 289, 021	64, 705	0. 29
Lard	...do	141, 970	2, 205, 241	2, 493, 729	4, 840, 940	63, 700	1. 83
Live stock:							
Cattle	Head	13, 631	157, 355	59, 554	230, 540	250	0. 11
Hogs	...do	98, 100	346, 271	453, 545	897, 916	7, 727	0. 86
Sheep	...do	22, 730	96, 767	86, 332	205, 829	954	0. 46
Horses and mules	...do	2, 369	4, 869	9, 934	17, 172	28	0. 16
Cereals:							
Flour	Barrels	27, 820	166, 908	81, 444	276, 262	3, 058	1. 10
Wheat	Sacks	658	302, 280	29, 343	332, 281	108, 554	
	Bushels	349, 150	1, 428, 950	908, 900			
Corn	Sacks	216	69, 180	6, 510	75, 915	54, 382	
	Bushels	502, 700	7, 988, 100	6, 925, 200			
Corn meal	Barrels	400	978				
Oats	Sacks		1, 086	19, 109	21, 095	3, 508	
	Bushels	89, 000	109, 800	1, 773, 800			
Rye	Sacks		48	575	623	81	
	Bushels	20, 350	454, 850	105, 600			
Barley	Sacks		420	614			
	Bushels	13, 200	138, 000	131, 400			
Rice				40			
Wines and liquors	Barrels	1	2, 419	298	2, 718	62	2. 28
	Box and cases		339	1			
Farm and dairy products:							
Potatoes	Bbls. and sacks	6	2, 282	737	3, 025	436	
	Bushels		16, 200	23, 400			
Onions	Sacks and bbls.		240	616	856	96	11. 21
Beans	...do	20	585	1, 768	2, 373	58	2. 44
Castor beans	Sacks	168	323	45	536	10	1. 87
	Bushels, bulk	2, 000	9, 500				
Flaxseed	Sacks	1, 394	2, 248	4, 450	8, 092	2	
	Bushels, bulk	22, 000	228, 500	21, 000			
Hay	Tons	780	5, 704	13, 266			
Tobacco	Hogsheads	830	372	6, 746	7, 948	456	5. 74
	Packages	2, 954	534	28, 522	32, 010	7	0. 02
Hops	Bales		60	260			
Molasses	Barrels	479	7, 306	65			
	Kegs		2, 815				
Butter	Pounds	9, 400	298, 076	295, 446	602, 922	9, 650	1. 60
Cheese	Boxes			3, 068			
Eggs	Packages	263	23, 443	6, 709	30, 415	3, 713	12. 21
Apples	Barrels	536	15, 782	12, 885	29, 203	1, 760	6. 03
Fruit, dried	Packages	[illegible], 744	2, 221	638	4, 603	429	9. 32
Minerals:							
Iron and steel	Tons	307	20	1, 889			
Lead, pig	Pigs	198, 365	150, 270	80, 763			
Pig-iron	Tons		60				
Coal	...do		750	349			
Lumber	Cars	26	94	165			
	M feet					399	
Ship chandlery:							
Hemp	Bales	40	44	111	195	21	10. 77
Flax, tow				432			
Tallow	Pounds	360, 870	1, 267, 856	489, 883	2, 118, 609	370, 609	17. 93
Grease	...do	175, 880	414, 049	614, 552	1, 204, 481	3, 609	0. 30
Peltries and furs:							
Hides	Pounds	1, 111, 478	2, 888, 869	860, 864	4, 861, 211	22, 195	0. 46
Wool	...do	1, 542, 358	2, 635, 027	1, 813, 976	5, 991, 361	48, 240	0. 81
Peltries and furs	Packages	689	5, 927	1, 596	8, 212	441	5. 37

TABLE 11.—*Receipts at Saint Louis from the West and shipments to the West, &c.*—Cont'd.

SHIPMENTS.

Articles.	Designation.	By rail. Chicago and Alton Railroad (Missouri division).	By rail. Missouri Pacific Railroad.	By rail. Wabash, Saint Louis and Pacific Railroad (western division).	By rail. Total by rail.	Missouri River.	Percentage by river.
Provisions:							
Pork	Barrels		274			7	
Hams	Pounds	28, 986	131, 345				
Meats	...do	38, 870	186, 661			759	
Lard	...do	23, 060	150, 871	34, 783			
Live stock:							
Cattle	Head	442	736	4, 823			
Hogs	...do	5	71	66			
Sheep	...do	100	127	1, 390			
Horses and mules	.. do	378	1, 726	1, 535			
Cereals:							
Flour	Barrels	277	2, 888	635			
Wheat	Sacks		561				
	Bushels	1, 585	5, 027	4, 550			
Corn	Sacks		174				
	Bushels		1, 250				
Corn meal	Barrels		65				
Oats	Sacks		2, 876				
	Bushels	800	10, 720	2, 470			
Barley	Sacks		10	189			
	Bushels		16, 660				
Rice	Packages	856	983	1, 766			
Malt	Sacks	3, 731	8, 285	3, 985			
Liquors:							
Whiskies and high wines.	Barrels	7, 845	18, 526	8, 882			
Beer and ale	Packages	34, 044	197, 195	154, 437			
Farm and dairy products:							
Potatoes	Sacks	2, 253	10, 240	13, 215			
	Bushels	2, 296	4, 384	950			
Onions	Packages	287	1, 064	175			
Beans	.. do	966	1, 608	579			
Flaxseed	Sacks		1, 350				
	Bush. (bulk)		2, 500				
Hay	Tons		226	22			
Tobacco	Hogsheads	311	19	707			
Tobacco, manufac	Packages	10, 631	76, 002	44, 045			
Molasses	Barrels	558	1, 431	1, 330			
	Kegs	448	1, 161	179			
Butter	Pounds	1, 490	5, 040				
Cheese	Boxes	1, 254	3, 501	727			
Eggs	Packages	39					
Apples	Barrels	3, 414	4, 793	3, 407			
Fruit, dried	Packages	3, 380	7, 782	1, 580			
Minerals:							
Lead, pig	Pigs	40	1, 020	4, 022			
White lead	Pounds	639, 260	2, 165, 865	558, 144			
Pig-iron	Tons	681	5, 773	1, 115			
Coal	...do	12, 488	177, 727	14, 238			
Lumber	M feet	2, 328	47, 960	19, 781			
Ship chandlery:							
Bagging	Rolls	39		35			
Soap	Boxes	3, 484	19, 212	3, 132			
Tallow	Pounds	24, 500	62, 575	40, 000			
Grease	...do	38, 390					
Peltries and furs:							
Hides	...do		269, 977	28, 000			
Wool	...do	13, 510	36, 915	306, 700			

TABLE 12.—*Statistics of Leavenworth, Kans., Saint Joseph, Mo., and Omaha, Nebr.*

LEAVENWORTH, KANS., 1884.

Articles.	Received.	Shipped.
Wheat .... bushels..	1,800,000	1,500,000
Corn .... do....	1,231,934	1,231,934
Oats .... do....	600,395	600,393
Rye .... do....	411,295	....
Flaxseed .... do....	75,000	....
Apples .... barrels..	....	100,000

Apples made into cider, about .... bushels.. 25,000
Apples, dried .... pounds.. 13,000

Mill using daily 500 bushels flaxseed, making daily 1,300 gallons linseed oil and 18,000 pounds linseed meal.

Factories of organs, candles, coopering (1,000 barrels a day), canning (over 1,500,000 in 1884), stove works, flouring mills.

OMAHA, NEBR., 1883.

[Missouri Pacific Railroad.]

Articles.	Car-loads.	
	Received.	Shipped.
Wheat and flax	57	154
Corn	78	213
Rye	4	1
Barley	10	5
Oats	7	50
Cattle and hogs	82	7
Horses and sheep	166	41
Flour	104	4
Lumber	1,097	307
Miscellaneous	5,915	2,644

[Union Pacific Railroad.]

	Car load shipments.		
	1881.	1882.	1883.
Cattle	304	590	1,366
Hogs	57	59	119
Horses	100	215	275
Sheep	40	30	89

[B. & M. R. R., 1883.]

Articles.	Car-loads.	
	Received.	Shipped.
Wheat and flax	203	1
Corn	61	8
Rye	1	1
Barley	84	....
Oats	19	1
Cattle and hogs	532	17
Horses and sheep	78	3
Lumber	205	466
Lime	338	79
Miscellaneous	10,608	3,445

TABLE 12.—*Statistics of Leavenworth, Kans., Saint Joseph, Mo., &c.*—Continued.

[Miscellaneous trade.]

	1882.	1883.
Smelting works, freight handled ....tons..	77,348	110,119
Bluestone product ....do..	....	575
Linseed oil, daily capacity:		
Flaxseed ....bushels..	....	2,000
Flaxseed oil ....gallons..	....	4,000
Flaxseed oil cake ....pounds..	....	80,000
Crackers (daily capacity), flour ....barrels..	....	425
Brick, made	....	35,000,000
Nails, yearly capacity ....kegs..	....	200,000

SAINT JOSEPH, MO.

	Car loads of stock received at Union Stock Yards.		Estimated number of heads.	
	1885.	1884.	1885.	1884.
Cattle	762	826	15,740	16,3[illegible]
Hogs	2,447	2,298	146,820	137,[illegible]
Sheep	51	43	5,100	4,[illegible]
Horses and mules	437	361	6,992	5,17[illegible]
Total	3,662	3,994	174,152	164,[illegible]

[Saint Joseph manufacturing interests, 1885.]

Kind of manufacture.	Capital employed.	Number of hands employed.	Aggregate of wages paid.	Value of products.
Refineries	$225,000	45	$20,000	$180,[illegible]
Woolen mills	450,000	100	50,000	700,7[illegible]
Flour and feed mills	600,000	200	70,000	1,500,1[illegible]
Breweries and bottling	400,000	175	75,000	500,[illegible]
Foundries, machine and car shops	1,000,000	550	305,000	1,750,[illegible]
Furniture and show-cases	275,000	250	200,000	850,[illegible]
Brick-yards	200,000	250	100,000	375,[illegible]
Contracting	220,000	1,150	300,000	1,500,[illegible]
Stone and marble yards	100,000	300	45,000	450,[illegible]
Harness and saddlery	160,000	120	50,000	200,[illegible]
Printing, publishing, and binding	200,000	325	150,000	350,[illegible]
Planing-mills	65,000	130	80,000	445,[illegible]
Plows and implements	45,000	75	40,000	240,[illegible]
Boots and shoes	80,000	160	60,000	240,[illegible]
Canning, drying, and preserving	80,000	175	40,000	85,[illegible]
Slaughtering and packing	1,600,000	260	70,000	1,400,[illegible]
Miscellaneous	1,000,000	1,500	70,000	3,175,[illegible]
Carriage and blacksmith	85,000	180	60,000	240,[illegible]
Total	6,785,000	5,915	1,785,000	14,260,[illegible]

[From statement of wholesale and retail trade of the year from September, 1884, to October, 1885.]

Articles.	Aggregate sales.	Articles.	Aggregate sales.
Dry goods	$10,155,000	Flour, feed, and mill-stuffs	$2,750,1[illegible]
Groceries	12,600,000	Wool, hides, tallow, and furs	1,170,[illegible]
Hardware, iron and cutlery	4,510,000	Coal	1,725,[illegible]
Lumber and building materials	4,120,000	Leather and findings	338,[illegible]
Grain and produce	5,625,000		
Live stock	4,250,000	Total	49,705,[illegible]
Machinery and agricultural implements	2,462,000		

TABLE 12.—*Statistics of Leavenworth, Kans., Saint Joseph, Mo., &c.*—Continued.

[Grain purchased during the same period.]

Articles.	Aggregate quantity.	Articles.	Aggregate quantity.
	Bushels.		*Bushels.*
Wheat	430,000	Barley	240,000
Corn	4,100,000		
Rye	260,000	Total	5,350,000
Oats	320,000		

TABLE 13.—*Average rates of freight on wheat in cents per bushel.*

[Steamer from Saint Louis to Liverpool via New Orleans.]

Months.	Saint Louis to New Orleans.			New Orleans to Liverpool.			Total Saint Louis to Liverpool.		
	1883.	1884.	1885.	1883.	1884.	1885.	1883.	1884.	1885.
January	9	6½	......	16	9	10	25	15⅛	......
February	9	6½	......	15½	6	10	24½	12⅝	......
March	7	6½	7	15⅝	7	10½	22⅝	13⅛	17½
April	5¾	6½	6	13	6	10½	18¾	12⅝	16½
May	5¾	5⅝	5⅛	11	7⅛	12	16¾	13	17⅛
June	5½	5½	5⅛	11	5⅝	......	16⅝	11	......
July	5½	3½	5⅛	12	8	4	17⅛	13⅛	9⅛
August	5¾	7	6⅛	14	13⅛	7⅛	19¾	20⅛	14
September	6⅛	7	6⅛	11	11	8½	17⅛	18	15
October	7½	7	6⅛	10⅝	4	8½	17¾	11	15
November	6¾	7⅛	7⅛	13⅝	9	8⅛	20½	16⅛	15
December	6⅝	7⅛	7⅛	12	10	9	18⅛	17⅛	16⅛
Average	......	......	......	......	......	......	18¾	$14\frac{7}{12}$	*14

[Saint Louis to Liverpool via rail to New York.]

Months.	East Saint Louis to New York.			New York to Liverpool.			Total Saint Louis to Liverpool.		
	1883.	1884.	1885.	1883.	1884.	1885.	1883.	1884.	1885.
January	21	20	$17\frac{4}{10}$	14	5⅝	9	35	25⅝	26.40
February	21	16⅝	$17\frac{4}{10}$	13	5	6½	34	21⅜	23.90
March	21	12	$17\frac{4}{10}$	7¾	8⅛	7	28¾	15⅛	24.40
April	21	12	$17\frac{4}{10}$	7	$8\frac{55}{100}$	7⅜	28	$15\frac{55}{100}$	25.05
May	$17\frac{4}{10}$	12	$17\frac{4}{10}$	5⅛	2⅝	4¾	$22\frac{8}{10}$	14⅛	22.15
June	$17\frac{4}{10}$	12	9	5⅛	6	4¾	$22\frac{33}{50}$	18	13.75
July	$17\frac{4}{10}$	15¾	$13\frac{8}{10}$	8	9	4⅛	$25\frac{9}{20}$	24¾	18.13
August	$17\frac{4}{10}$	15¾	$11\frac{4}{10}$	7	9⅛	5⅛	$24\frac{4}{10}$	$24\frac{7}{8}$	16.55
September	$17\frac{4}{10}$	15¾	6	7	6	7⅜	$24\frac{4}{10}$	21⅛	13.60
October	$17\frac{4}{10}$	15¾	$13\frac{8}{10}$	9	8	5⅛	$26\frac{4}{10}$	23¾	19.00
November	$17\frac{4}{10}$	15¾	$13\frac{8}{10}$	9	11⅜	5⅛	$26\frac{4}{10}$	$27\frac{7}{80}$	19.15
December	$20\frac{4}{10}$	15¾	$17\frac{4}{10}$	5⅛	13¾	6⅛	$25\frac{8}{10}$	29⅛	23.90
Average	......	......	......	......	......	......	$27\frac{1}{30}$	$21\frac{9}{130}$	20⅛

* For nine months.

Transfer at New Orleans ½ cent per bushel; insurance ¾ to 1 per cent.

I.

[Extract from Report of the Chief of Engineers 1868, page 622.]

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, December 3, 1867.

COLONEL: In continuation of the duties designated in your order dated June 24, 1867, I have the honor to submit the following report:

* * * * * * *

COMMERCE.

The commerce of the Missouri, although not equal to the natural demands of the country dependent upon it, is steadily increasing in importance, and will continue its growth to meet the necessities of our northern Territories as their resources are developed and navigation is rendered more safe and speedy. At present the commerce above the rapids is concentrated at the two ports, Camp Cooke and Fort Benton, the former receiving only army and sutler's supplies for the military post established there, and the latter receiving supplies for the mining country of Montana for the military posts of Fort Benton and Sun River, and for the northern Indians.

During the season of 1867 43 steamboats engaged in this trade cleared from the port of Saint Louis; of these one made 2 round trips. Two on the second trip were unable to pass Dauphin's Rapids, and left their freight at Cow Island; one on the first trip could get no higher than Fort Hawley, and the steamer Imperial on the first trip discharged freight at Cow Island, and is now on her return, last reported November 20 at Saint Joseph, with 300 passengers and a large consignment of specie. The J. H. Prover was wrecked at Point au Poche, the Nora sunk near De Soto, the Deer Lodge had her shaft broken by drift near Decatur, and gave up her second trip.

Of the freight carried by this fleet 2,095 tons belonged to Government, 5,966 to private parties, making a total of 8,061 tons, dependent on the navigation of the rapids section of the river. Of the return cargoes I can give but little information. Hides, peltries, gold, silver, and copper are the only exports, and all seek river transportation.

It is safe to say that five-sixths of the mining products of Montana reach the East by way of Missouri River. The passenger traffic is also an item of considerable importance, and it is estimated that 10,000 persons during this season have taken this route to and from Montana, at an average rate of $150 each, making a total of $1,500,000 for payment of passages.

It is not expected that the river will in the future be the passenger route to Montana, for the reason that the trip can be made in much shorter time by the way of the Western Pacific Railroad and stage to the mines. Indian troubles may influence a few travelers, but the great majority will naturally seek the shortest and most speedy route, with its attendant risks. Travel from Montana in the spring and summer will, however, be by the river, the boats then being able to compete successfully in point of time with the stage route, besides furnishing a safer and more pleasant mode of traveling.

Nor does the river at present enjoy a monopoly of the Montana trade, owing to the high rate of river transportation, the present uncertainty of navigation, and insufficient number of boats employed. It has been found necessary and economical to transport by wagon trains from Utah, California, and the terminus of the Union Pacific Railroad a large proportion of the breadstuffs and sundries consumed in the Territory.

By removing difficulties of navigation this trade will naturally be directed to the East. Rates will be reduced. A large fleet employed on the river and the prosperity of Montana and of the river interest, mutually dependent, will rapidly increase.

In view of this mutual dependence projects have been set afoot for railroad communication between Helena, the capital of Montana, and the river. A railroad from the mouth of the Muscle Shell River is deemed feasible, thus cutting off the rapids.

With the rapids improved, a railroad from Fort Benton would be desirable. Montana is a thrifty, growing country, but its growth is greatly retarded by difficulty of communication. Even should it be attempted to overcome the difficulty by a railroad from the Muscle Shell or a branch from the Union Pacific Railroad, years will necessarily elapse before such roads can be made of use, and in the mean time the Missouri River must retain its importance.

Taking such views of the case, I esteem the improvement of the rapids of the Upper Missouri not only a necessity, but a duty the Government owes to a Territory that promises to be one of the most flourishing States, and a portion of that mountain belt whose settlement will do more towards settling the Indian question than can be done by a powerful and expensive army.

In the middle section of the Missouri the ports are only at military or fur-trading ssts, and are enumerated as follows: Fort Thompson, New Fort Sully, Fort Rice, ort Stevenson, Fort Berthold, Fort Buford, and Fort Hawley. Consignments to ese posts are either military supplies, Indian annuities, or the goods of fur-traders. uring the season of 1867 twenty-eight cargoes were cleared from Saint Louis for iese several points, amounting to 8,094 tons, of which Government shipped 5,832 ns and private parties 2,262 tons. The receipts from these ports are hides, horns, nd peltries from the fur companies.

The number of passengers, though not great, is yet considerable, mostly officers and ldiers, coming from and returning to their posts.

The lower section of the river, that is, from Saint Louis to Fort Randall, has, of cessity, from the fact of its winding through a fertile and well-populated country, e greatest commercial value, besides carrying all the commerce of the upper river; s own packet trade is perhaps as considerable as that of any Western river, and its rough trade from its great commercial center, Saint Louis, though competing with ilroad transportation is of fair importance.

From the 1st of February, 1867, to the 1st of October, 1867, from Saint Louis 212 earances are recorded for this section and 169 arrivals. Of the trade from Saint harles, Fort Leavenworth, Saint Joseph, and other important points along the seon, I am unable to furnish information, further than to say that it is very considable.

The Government freight transported on this section amounted during the above ght months to 6,000 tons, and was consigned to Fort Leavenworth and Omaha.

For details of exports and receipts at the port of Saint Louis, I will refer to the bles annexed and furnished me by the courtesy of Mr. George H. Morgan, secretary the Union Merchant's Exchange, Saint Louis.

For annexed list of Government freight, I am indebted to brevet Lieut. Col. C. W. homas, United States Army.

Navigation opens on the Lower Missouri on the breaking up of the ice about the st of February or the first of March, and continues good until the first or middle of ptember, when the river becomes so low as to cause great trouble from bars. Boats, wever, continue running until late in November, or, in favorable seasons, until Dember, when ice closes the season. For the middle section the channel is good until e 1st of August above the Yellowstone, and until the middle of August below. From e latter period until the 1st of November the channel is full of bars and difficult. ats have cleared from Fort Buford after the 1st of November, but at great risk.

In the upper section but little trouble is anticipated until the 1st of August; after at the rapids become quite impassable in ordinary seasons. The first boats for Fort nton start from Saint Louis the latter part of March, and encounter floating ice on e spring rise, above Randall. With boats specially built for the mountain trade e up trip is made in sixty to sixty-five days; the return in fifteen to twenty days. n the second trip the time to Benton ranges from fifty to sixty days.

During the last season many boats not adapted to the river attempted the trip to nton and without success. The Centralia started June 12, and was eighty-two ys in reaching Fort Hawley; thirty-five on return. The Imperial started May 17, d was eighty-six days in making Cow Island; other boats made equally long trips. he increasing demands of the up-river trade caused this addition to the mountain et, and has proven the impolicy of sending any but light-draught powerful steamers Fort Benton, except at the commencement of the season.

Parties interested in the upper river begin to recognize the necessity of a higher itial point than Saint Louis. Sioux City will probably soon become the rendezvous the mountain fleet, since from that point the trip will be much shortened, the ngers of the lower river avoided, and two round trips to Benton assured. Rates of eight and insurance will be greatly reduced, and the commercial interests of Chicago ill come in direct competition with those of Saint Louis, cheapening the value of goods the consumer in Montana. Should it be decided to communicate with the river by agon trains, at the mouth of the Muscle Shell, boats can make from four to five trips a season with ease, by starting from Sioux City, thus diverting the whole Montana ade to the river. The map of the river, now being made under my direction, will ot be finished until late in February, when it will be submitted.

For details of my tour of inspection of the obstructions in the river, and of the ver commerce, I refer you to the papers accompanying this report. For kind atntion and material assistance in performing the duty intrusted to me I am greatly debted to Captain Hawley and the officers of the steamer Miner.

For many civilities and much useful information, thanks are due to officers of the rmy stationed at the various military posts along the river.

In conclusion, I have the honor to be, sir, very respectfully, your obedient servant,

C. W. HOWELL,
Captain Engineers, Bvt. Major, U. S. A.

Col. JOHN N. MACOMB,
Corps of Engineers, U. S. A.

II.

[Extract from Report of the Chief of Engineeer, Part I, 1878.]

SPECIAL REPORT ON IMPROVEMENT OF THE MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

UNITED STATES ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF DAKOTA,
Saint Paul, Minn., January 3, 1878.

GENERAL: I have the honor to transmit herewith a report upon "The improvement of the Missouri River above the mouth of the Yellowstone."

* * * * * * *

THE SECTION OF COUNTRY TO BE SPECIALLY BENEFITED.

The section of country to be specially benefited by the improvement of the Upper Missouri River is the Territory of Montana, which lies about midway between the great lakes and the Pacific Ocean. Embraced between the forty-fifth and forty-ninth parallels and 104° and 115° west longitude, it is 276 miles wide from north to south and a little over 520 miles wide from east to west. It contains 143,776 square miles, above one-tenth of which (9,000,000 of acres) is farming land. About one-fourth of the inhabitants are miners, one-eighth stockmen, and the remainder tradesmen and professional men.

All crops are planted in May, with the exception of winter wheat, which is sown in October.

Hay is cut and stacked in July, and retains its natural green color until used. This peculiar characteristic is remarkable, and it is said that a load passing along the street at Christmas has the color and perfume of new-mown hay.

The greatest yield in the line of vegetables is in potatoes, turnips, and onions.

Strawberries of the finest varieties ripen in July, thus furnishing a luscious berry in the warmest month of the year at the rate of 40 to 50 cents a quart.

Tomatoes do not ripen until September.

Some apples are grown in the Territory, but not to any great extent.

The experiments of the Sisters of Saint Ignatius Mission have shown that the country is adapted to the growth of apples, plums, and all varieties of berries.

The spring-wheat flour of Montana is white, of fine quality, and makes most excellent bread, while its buckwheat and corn-meal are said to be equal to the best varieties of those articles in the States.

The chief exports of Montana at present are ores, furs, hides, wool, and cattle.

The imports are machinery, manufactured articles, merchandise, and supplies, such as sugar, coffee, tea, &c.

Mr. George Clendennin, jr., informs me that the greater portion of the furs and robes are collected from the Blackfoot Agency, the Marias, and Milk River trading-posts, and from the British possessions, and that Benton is the point from which they are shipped to the East. Benton receives annually about 100,000 robes and furs, and the Crow Agency, south of the Yellowstone, about 5,000. About 20,000 pounds of skins are received annually at the Crow Agency, and at Benton 150,000 pounds. Over 200,000 pounds of wool are annually shipped to the East. This quantity will gradually increase, and wool of a fine quality will become the great export of Montana.

The beef of Montana is the best in the world, and its mutton rivals the celebrated Southdown. The ease with which large herds are raised, and the comparatively slight cost of maintaining them, will undoubtedly cause Montana in the future to furnish the Eastern markets with an article of food which will be not only of a finer quality but cheaper than that with which they are now supplied. The valley of the Muscle Shell and the beautiful Judith Basin must be developed into magnificent grazing-farms. The herds in Montana are not housed and fed during the winter, but roam at will, and subsist on the plentiful, luscious, and nutritious grasses all the year round.

Of the shipments to the Territory, about one-fourth are to Benton and the remainder to Helena via Benton. Helena, the principal distributive depot, is about 140 miles from Benton, the transportation between the two places being by means of wagon trains.

The establishment of three new posts, and the increase of the number of troops stationed in the Territory, will give an impulse to the settlement of the country by at least a partial removal of the two barriers to such settlement—insecurity of life and property.

In regard to the mineral wealth of the Territory, it has been said that as a gold-bearing country Montana stands next to California, and in silver she ranks first in quality possessed, and second to Nevada in the amount produced.

To enter fully into a discussion of the mining interests is unnecessary for the purposes of this report, the comprehensive and interesting reports of the commissioner of mining statistics being accessible. A few leading facts are, however, here set down.

In his report for 1874, the commissioner gives the following exhibit of the productions for the different years:

Years.	Amount.	Years.	Amount.
1869	$9,000,000	1872	$6,068,330
1870	9,100,000	1873	5,178,047
1871	8,050,000	1874	3,844,722

He says that the decrease of the gold yield is entirely due to placer mining. These narrow and rich gulches and bars, to which short ditches could be built by two or three men, have been exhausted. To work the gold-bars which abound in the numerous valleys, it is necessary to construct long and large ditches, and this can be done only by companies having abundant capital at their command. It is expected, therefore, that there will result a consolidation of the mining-ground heretofore owned in small parcels, and that the yield will be increased provided labor does not remain too high.

The shipments of silver ore are gradually increasing, and with the introduction of quartz-mills the gold yield will undoubtedly become greater. Millions of tons of ore now lie worthless at the mines on account of high rates of transportation.

Montana coal, which is abundant in all parts of the Territory, can be used, as it now is, for blacksmithing, for making steam for locomotives and steamboat purposes, as well as for making gas and smelting iron, galena, and, in short, for every purpose for which soft Pennsylvania coal can be used. According to the reports of the Secretary of the Interior, about 70,000 square miles, or half of Montana, is underlaid with coal-beds; but this I regard as an over-estimate.

Iron ore is equally abundant, and in time Montana can alone supply the needs of the western half of the continent with iron.

In regard to the use of the coal for steamboats I would add that the varieties of Montana coal (lignite) which I have seen are unfit for such purposes, if used alone, on any boat which is not furnished with locomotive boilers. It is difficult of ignition and the flame is short. But if used with wood it causes a saving in that article by keeping up a hot body to the fire, while the wood supplies the long, lapping flame.

THE VALUE OF THE MISSOURI RIVER AS A LINE OF COMMUNICATION AND TRANSPORTATION.

The Missouri River and the common roads connecting the Territory with the Union Pacific, Central Pacific, and Utah Northern railroads are at present the only regular lines of communication with Montana. Of these the river is by far the most important. It is *the* great route.

The completion of the Union Pacific and the low water of 1869 induced the merchants and shippers of Montana to contract for the transportation of their freight by the railroad, it having lowered its rates during the season of high water in order to compete with the boats. Time, however, proved the superiority of the water route in spite of the obstacles to navigation, and the bulk of imports returned to the river.

The Helena Independent, in one of its editorials, says of the river:

"Freights can be laid down at Benton at such a low rate that successful competition from any other source is next to impossible. At any rate it is the route that Montana must look to for cheap freights until she gets a railroad, and therefore it is the duty of her people to put forward their best efforts to secure measures that will aid in making this great natural highway available for the immense commerce that will pass over it for the next ten years. It is desirable that the river navigation should be kept up from the time ice breaks up in the spring until it is closed in the fall by ice."

The above-quoted statements are true; but should be stronger in this, that the Missouri River will alway be an important line, no matter how many railroads may be built in Montana.

It is the intention to carry the Northern Pacific Railroad along the south bank of the Yellowstone. This road will, of course, receive part of the freight to and from Montana, as does the Union Pacific at present, but there is a large extent of the Territory which, from its greater convenience to the river, and from the very nature of its productions, must find an outlet for those productions in the Missouri.

It is impossible to say when the Northern Pacific will be finished or in operation, and it is also impossible to state what the freight rates on that road will be. But whatsoever they may be, the Missouri River will always receive the bulky matter, as better adapted to its carriage at rates to which the railroad cannot safely descend; and it will also by its competition keep at a reasonable figure the rates on those articles which will naturally seek the railroad for rapid transit. The river, then, will be indispensable, not only as a line of transportation, but as serving by its competition to keep down the freight rates on the railroads.

* * * * * * *

It is proposed now simply to submit such an exhibit of the commerce of the river last season as the information which could be obtained will permit.

Messrs. J. G. Baker & Co., of Benton, who ship over one-fourth of the freight which goes up the river, have, in compliance with my request, kindly furnished me with the following information:

During the last season 25 steamers arrived at Benton, landing 5,283 tons of freight and about 1,500 passengers. These boats carried down the river 3,200 tons of freight and about 500 passengers.

The imports consisted of merchandise for the merchants of Montana, supplies for the Army and Indians, and the Northwest Mounted Police of Canada.

The exports consisted of ore, wool, hides, and furs; principally of ore.

Owing to the Indian troubles, only six steamers landed at Cow Island, parties fearing to ship freight by that route, as it would have to be carried overland in wagons to Benton.

The additional cost of transportation *via* Cow Island has been 2½ cents per pound, or about three times as much as it would have been if boats could have carried the freight to Benton.

The average amount of freight landed at Cow Island annually is 500 tons, causing an extra annual expense to the Government and citizens of $25,000. In addition to this, both the Government and citizens ship by the Union Pacific Railroad (a circuitous route, requiring 450 miles of wagon transportation) at a heavy expense. This causes a difference in freight of at least $75,000. This would not occur were the river navigable during the whole season. Since 1870 the commerce of the river has increased 50 per cent.

During the month of September about 60 tons of Government freight were burned at Cow Island by the Nez Percés. This freight was lying at the landing awaiting transportation to Benton, and the loss could not have occurred if the boats had been able to reach the latter place.

The number of troops stationed in Montana has been increased, and it naturally follows that a greater amount of supplies will be sent to the Territory hereafter. It would be a great saving to the Government to be able to ship these supplies direct to Benton by boat, and thence haul them by wagons to the different posts, at the rate of 1½ cent per 100 miles.

The following is a classified schedule of exports, *via* the river, for 1877:

	Quantity.	Value.
EXPORTS.		
Ore and bullion....tons..	*1,225	$918,750 00
Wool....pounds..	208,459	72,[illegible]
Buffalo-robes....	50,512	202,048 00
Antelope, elk, and deer skins....pounds	68,530	12,335 40
Bear skins....	61	305 00
Wolf skins....	2,034	7,703 [illegible]
Beaver skins....pounds..	6,703	6,703 00
Hides....	15,267	45,801 00
Mixed furs....	....	2,150 00
Sheep skins....	1,482	592 50
Cattle....head..	112	2,240 00
Fort Macleod shipments....tons..	595	303,000 00
Cypress shipments....do...	350	180,000 00
IMPORTS.		
Montana freight....tons..	†4,648	1,394,400 00
Canadian freight....do...	1,025	310,000 00

* Average value per ton, $750. † Average value per ton, $300.

Of these imports, 390 tons were landed at Cow Island. The total value of the commerce of the river was $3,458,536.60.

It is perhaps well to state here that the river is navigable to Benton from about May to the middle of August, and that from the latter date to about the middle of October boats land their freight and passengers at Cow Island.

The fact that freight must be rehandled at Cow Island (rehandling being always a source of increased expense), and that transportation by wagons is more costly than that by boats, has led the people of Montana to ask that the river should be improved in order that the annual period of navigation to Benton may be extended.

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Very respectfully, your obedient servant,

EDWD. MAGUIRE,
First Lieutenant of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

III.

[Extract from Report of the Chief of Engineers, Part II, 1879.]

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., August 12, 1879.

GENERAL: I have the honor to forward herewith my annual reports for the fiscal year ending June 30, 1879, upon the improvement of the Missouri River above the mouth of the Yellowstone, and upon the survey of the Yellowstone River.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
First Lieutenant, Corps of Engineers

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

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COMMERCE.

The number of steamboat arrivals at Benton was 46, an increase of 21 over 1877. The freight carried up the river amounted to 8,764 tons, of a value of about $2,631,300, showing an increase over 1877 of 3,091 tons, of an approximate value of $927,300. Maj. William B. Hughes, quartermaster U. S. A., under date of October 16, 1878, informed me that he had shipped from Yankton, Dak., for the Missouri River above Buford, 261,131 pounds of Government freight. Capt. E. B. Kirk, assistant quartermaster U. S. A., informs me that the Government freight shipped up the river from Buford amounted to 94,424 pounds.

I have been unable to obtain a full exhibit of the exports, but the amount of wool shipped down the river was 696,000 pounds, an increase over 1877 of 487,541 pounds. For purposes of comparison, the value of the wool is assumed as that of 1877 shipments; hence the money value on the increase shipment amounted to about $169,639, or the total value of the 1878 wool was $242,599.

Six of the descending boats were loaded with cattle. It is safe to assume that the amount of other articles of export did not fall below that of 1877. The amount of freight carried up the river will hereafter be greater, on account of the establishment of a large post, Fort Assinnaboine, on Milk River, about 40 miles north of the Missouri.

THE YELLOWSTONE AS A LINE OF COMMUNICATION AND TRANSPORTATION.

The section of country to be specially benefited by the improvement of the Yellowstone is, of course, the Territory of Montana. Reference will be made to the productions of the territory in general, but more particularly to the region adjacent to the river in question.

The valley of the Yellowstone is not inferior to other sections of Montana. The soil is as good, the grasses as fine, and the region south of the river in the neighborhood of Clark's Fork and its tributaries is rich in valuable ores. The Commissioner of Mining Statistics, in his report for the year ending December 31, 1874, says:

"From Mr. John Barnett, an old prospector in this region, Mr. Wheeler procured some fine specimens of ore, containing from 70 to 80 per cent. of lead, which he had found at the headwaters of Soda Butte Creek, a tributary of Clark's Fork of the Yellowstone, near the east boundary of the National Park.

"Blackmore and New World mining districts have been located here, taking in 12 miles from east to west and 6 from north to south. They contain a large number of

well-defined leads. The mountains, as Mr. Barnett describes them, are covered with wash-bowlders of galena, and the veins, so far as tested, are from 6 to 25 feet wide.

"A tunnel across the Mammoth vein in the New World district shows 25 feet of solid ore, and the width of the vein is not known.

"The New Caledonia shows a well-defined 6-foot vein. The Great Republic, Gurley, Ironclad, Houston, Woody, Silver Zone, Silver Gift, Blackfoot, Shoo-Fly, Alta California, Alta Montana, and a large number of other veins, have been located but not developed. There is an abundance of wood and water for all purposes. A few miles of road-building would make the mines accessible for wagons. The ores could then be hauled in vast quantities to or near the Crow Agency, on the Yellowstone.

"From crude assays, these ores will yield from 50 to 200 ounces of silver per ton, and from 70 to 80 per cent. of lead. The mines are about 110 miles southeast of Bozeman."

In his report of April 11, 1876, the Commissioner says:

"The Clark's Fork mines show on the surface large quantities of galena and silver ore, very rich in galena—60 to 80 per cent.—and in silver-bearing from $40 to $600 per ton, according to the tests that have been made. * * * A company has been formed to begin their development; but it will take both time and money to make them profitable. *The improvement of navigation on the Yellowstone would bring steamboats within 100 miles of them.*"

He says, further, that quartz mining is on the increase all over the Territory, while the yield of placer mines is slowly diminishing year by year.

More retort gold from arrastras and small stamp-mills has been sold in 1875 than ever before, and less dust from placer mines.

The number of tons of silver ore worked and shipped in 1875 is very nearly double the quantity worked and shipped in 1874.

The copper interest is growing.

Mr. Wheeler estimates the yield of gold, silver, and copper during the year 1875 as worth $3,596,100. This was the amount actually realized, "but at the close of the year there were more tons of silver and copper ores at the mouth of the mines prepared ready for shipment, of equal average value per ton, than were shipped during the year; and 100,000 tons of ores, running from $40 to $150 per ton, that will not bear shipment, are piled by the dumps for future working or awaiting cheaper transportation."

Want of transportation is the continual cry in Montana, and, in a great measure, limits the yield of the mines.

A remedy is hoped for in railroads or the improvement of the navigation of the Missouri and Yellowstone rivers, by help of Congress, for which the legislature has forwarded a memorial.

Mr. William F. Wheeler, formerly United States marshal, informs me that the mineral yield for the year 1877 was $4,151,000 in value.

But the mineral wealth of Montana is of secondary importance compared to her value as a stock-raising and wool-growing section, being unsurpassed in the trans-Missouri country. The number of beef cattle driven and shipped from the Territory in 1877 amounted to 12,500 head, of an approximate value of $250,000. The total wool shipment was 310,000 pounds, of an approximate value of $108,500.

The improvement of the navigation of the Yellowstone will certainly give rise to an increase of population, and hence an increase of productions and shipments.

As stated above, the Yellowstone Valley is not inferior to other sections of the Territory, and is rapidly being settled. In a report forwarded to the Chief of Engineers, March, 1877, I expressed the opinion that, agriculturally considered, the valley of the Yellowstone could be classed as "fair." It was only on an overland trip last fall from Fort Keogh to Fort Buford that I was enabled to fully appreciate its full value. As late as 1876 almost every foot of this valley was in the undisputed possession of the Indians. Now there are settlements of white men, the river bank is lined with wood-yards, where the laboring steamboats may purchase fresh supplies of fuel; the traveler encounters, every few miles, ranches with claims under cultivation, producing great varieties of vegetables and cereals, besides the luxury of melons, while the fertile bottom lands and gentle slopes are dotted with stock, grazing upon the bunch and buffalo grasses with which the land is thickly carpeted. Irrigation is a problem of easy solution, demanding an expenditure of but little labor and money, and such cheap and successful irrigation fulfills the only condition requisite in this region for the profitable growth of all kinds of grain. There is plenty of timber, and the valley is intersected by numerous streams of clear, sweet, running water.

The principal town of this section is Miles City, the seat of Custer County. It is beautifully situated on the east bank of Tongue River, in sight of the Yellowstone, and at present has a population of about 1,000 souls. It is a prosperous and thriving town, apparently free from much of the disorder and lawlessness so characteristic of frontier settlements.

Coulson City, about 6 miles above Baker's battle ground, is the highest point ever

eached by a steamboat. I have never seen this town, and have been unable to obtain any definite information concerning it. It would appear that it owes its origin to the fact that as far as known its site is the head of navigation on the Yellowstone, and that it was expected that it would be the transfer depot of supplies for the lower portion of Montana.

I was unable to obtain any reliable information from the citizens along the river of the amount and value of the freight carried up the Yellowstone last year. Capt. E. B. Kirk, assistant quartermaster U. S. A., estimates the amount of private freight last year as 1,000 tons, of an approximate value of $300,000. Large amounts of freight were later in the season carried overland by wagons. The total amount of Government freight was about 5,083 tons.

The river is at present the main line of transportation connecting the two large posts, Forts Keogh and Custer, with the east. The Northern Pacific Railroad is in progress of construction to the Yellowstone, and it is the intention to carry it up the valley of that stream. This road will, of course, detract somewhat from the value of the river, but a healthy competition will arise and result in a benefit to the people of Montana. The river will always receive its share of the freight, especially of the bulky class, and of such articles as do not demand an immediate market, since it is better adapted to their carriage, at rates to which the railroads cannot safely descend. It will also, by its competition, keep at reasonable figures the rates on those articles which will, other things being equal, seek the railroad for rapid transit.

The Northern Pacific probably will not for years have any local business on the long stretch of over 200 miles from Bismarck to the point where it will strike the Yellowstone, and naturally freight rates to and from Montana will be high, unless kept down by competition. It will be only for the western portion of the Territory that the Union and Northern Pacific railroads will compete, and consequently the Yellowstone will be the only line of transportation for the southeastern section to rival the latter railroad.

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IV.

[Extract from Annual Report of the Chief of Engineers, U. S. Army, Part II, 1881.]

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 13, 1881.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river improvements in my charge, for the fiscal year ending June 30, 1881.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

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STATISTICS.

Capt. E. B. Kirk, assistant quartermaster U. S. Army, informs me that during last season there were shipped from the depot at Bismarck for points on the Missouri River 9,036,818 pounds of military stores.

Capt. D. D. Wheeler, assistant quartermaster U. S. Army, informs me that during the season of 1880 there were shipped from Yankton to points on the Missouri River 15 head cattle, 11 horses, 135 mules, and 2,595,132 pounds of stores.

Lieut. Francis Woodbridge, Seventh Infantry, acting assistant quartermaster, informs me that during the season of 1880 there were shipped from Fort Buford, Dak., for the Upper Missouri River 661,971 pounds stores and 1 horse.

From the River Press, of January 5, 1881, published at Fort Benton, I obtain the following information: "The total amount of freight, exclusive of Government freight, carried into the Territory by the river was 16,913,693 pounds."

I have been unable to obtain a full exhibit of the exports, but the amount of wool shipped by the river was 600,000 pounds. It is safe to assume that the amount of other articles of export was not less than that of previous years.

The total shipments of hides, pelts, furs, &c., from the Territory, by rail and river, amounted to 680,000 pounds. The exports of Montana, crude and refined silver and other bullion, for 1880 amounted to 10,913,407 pounds. During the year there were 10,000 head of beef steers driven to the eastern market and to the British possessions

Summary of river freight, exclusive of exports and Indian Department freight.

	Pounds.
Private freight	16,913,693
Government freight from Bismarck	9,036,818
Government freight from Yankton	2,595,132
Government freight from Fort Buford, Dak	661,971
Government freight from Cow Island, Mont	3,392
Government freight from Coal Banks, Mont	48,219
Government freight from Fort Benton, Mont	48,815
Total	29,308,040

Or about 14,654 tons.

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IMPROVEMENT OF YELLOWSTONE RIVER, MONTANA AND DAKOTA.

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STATISTICS.

Capt. E. B. Kirk, assistant quartermaster U. S. Army, informs me that during last season there were shipped from the depot at Bismarck for points on the Yellowstone River 2,192,173 pounds of military stores.

Capt. D. D. Wheeler, assistant quartermaster U. S. Army, informs me that during the season of 1880 there were shipped from Yankton to points on the Yellowstone River 30 mules and 479,015 pounds of stores.

Lieut. Francis Woodbridge, Seventh Infantry, acting assistant quartermaster, informs me that during the season of 1880 there were shipped from Fort Buford, Dak., to points on the Yellowstone River 1 horse and 222,263 pounds of stores.

Capt. A. R. Nininger (formerly captain, United States Army) informs me that the exports of Montana last season, by the Yellowstone, amounted to about 600 tons of hides, pelts, furs, &c.; that shipment will be nearly double this season. New towns are springing up in the valley, and the settlements are rapidly increasing.

Maj. F. P. McElrath, land commissioner at Miles City, informs me that there were twenty-four steamboat arrivals at Miles City during the season of 1880, averaging 250 tons of freight per boat, or a total of 6,000 tons, which included Government freight.

Summary of river freight, exclusive of Indian Department freight.

	Pounds.
Exports	1,200,000
Private imports	8,810,319
Government freight from Bismarck	2,192,173
Government freight from Yankton	479,015
Government freight from Buford	222,263
Government freight from Big Horn Depot	22,138
Government freight from Fort Keogh	274,0[illegible]
Total	13,200,000

Or about 6,600 tons.

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V.

[Extract from Annual Report of the Chief of Engineers, U. S. Army, Part II, 1882.]

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 8, 1882.

GENERAL: I have the honor to submit herewith my annual reports upon the works of river improvements in my charge for the fiscal year ending June 30, 1882.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

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COMMERCIAL STATISTICS [MISSOURI RIVER].

Five lines of steamboats make their headquarters at Bismarck, Dak., and from 20 to 30 boats ply between that town and points on the Missouri River, making during the season of navigation from one hundred and fifty to one hundred and seventy-five trips. The business for 1881 was in excess of that of any previous year. There were 21 boats employed, the largest being the Dacotah, with a freight capacity of 1,400 tons, and the smallest with a freight capacity of 250 tons. These boats carried into Montana 27,560,000 pounds of private and 7,200,000 pounds of Government freight, making a total of 34,760,000 pounds, valued at $5,214,000.

In addition, there were transported 1,300 passengers, 2,400 Indians, 1,800 head of horses and cattle, and 600 head of sheep. The exports, as far as learned, were as follows: 23,000 buffalo hides, valued at $37,500; 180 tons wool, valued at $90,000; 253,750 pounds of hides, pelts, &c., valued at about $76,125; and also an unestimated quantity of furs and wolf skins.

The steamboat owners estimate that the business this season will exceed that of last year. The rapid settlement of the country tributary to Benton and the Judith Basin will call for large shipments by river in the future.

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COMMERCIAL STATISTICS [YELLOWSTONE RIVER].

Five lines of steamers make their headquarters at Bismarck, Dak., and from 20 to 30 boats ply between this town and points on the Missouri and Yellowstone, making during the season of navigation from one hundred and fifty to one hundred and seventy-five trips.

The steamboat business for 1881 was greatly in excess of any previous year. There were 21 boats employed, the largest being the Dacotah, with a freight capacity of 1,400 tons, and the smallest the General Tompkins, with a freight capacity of 250 tons.

The freight carried up the Yellowstone River amounted to 8,420,000 pounds, of an estimated value of $1,263,000. The exports were principally hides, furs, and skins. There were shipped 93,000 buffalo-robes, of a value of $232,500, and about 263,000 pounds of hides, valued at $95,533, besides a quantity of furs and wolf skins. The above values are those on the river bank.

The Northern Pacific Railroad has tapped the Yellowstone Valley at Glendive, and it is hardly possible that there will be any freight carried on the river above Glendive as long as the railroad freight rates remain reasonable. But from Glendive to the mouth is a stretch of river which may be made very useful as a line of transportation for Benton and other Upper Montana freight. The long river haul of 303 miles from Bismarck to Buford would thus be saved by a down-river haul of about 100 miles. Hence it is proposed to confine the work of the coming season to that portion of the river. The work will consist in completing the dam at Katie's Island by raising it a foot higher, removing rocks and snags from the channel at the foot of Katie's Island, constructing dams at Glendive Shoal and Stanly's Shoals, and removing the few rocks and snags which are to be found between those points.

There are several other places which need improvement, particularly the mouth. There are in the lower reach a number of snags and overhanging trees which should be removed. I am confident that a channel at least 3½ feet deep can be obtained and maintained during the season of navigation.

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VI.

[Extract from Annual Report of the Chief of Engineers, U. S. Army, Part II, 1883.]

SAINT PAUL, MINN., *March* 17, 1883.

GENERAL: I have the honor to submit the following reports on the works in my charge.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

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COMMERCIAL STATISTICS.

The following is a classified schedule of exports and imports via the river as far as could be learned:

Articles.	Quantity.	Value.
EXPORTS, 1877.		
Ore and bullion .... tons..	1,225	$918,750 00
Wool .... pounds..	208,450	72,900 75
Buffalo robes	50,512	282,048 00
Antelope, elk, and deer skins .... pounds..	68,530	12,335 40
Bear skins	61	305 00
Wolf skins	2,034	7,051 45
Beaver skins .... pounds..	6,703	6,703 00
Hides	15,267	45,801 00
Mixed furs	....	2,150 00
Sheep skins	1,482	592 80
Cattle .... head..	112	2,240 00
Fort Macleod shipment .... tons..	595	303,600 00
Cypress shipment .... do ..	350	180,000 00
IMPORTS, 1877.		
Montana freight .... tons..	4,648	1,394,000 00
Canadian freight .... do ..	1,025	210,000 00
The total value of the commerce of the river was	....	3,458,536 00

In 1878 the number of steamboat arrivals at Benton was forty-six. The freight carried up the river amounted to 8,764 tons, of an approximate value of $2,631,300. The Government freight shipped from Yankton, Dak., for the river above Buford amounted to 261,131 pounds, and the amount shipped up the river from Buford was 94,424 pounds.

The amount of wool shipped down the river was 696,000 pounds, and the amount of other articles of export was about the same as the previous year.

In 1880 there were shipped from Bismarck for points on the Missouri River 9,036,818 pounds of Government freight. From Yankton there were shipped to points on the Missouri River 2,595,132 pounds of Government freight, and from Buford there were shipped to points on the Missouri River 661,971 pounds of Government freight. The amount of wool shipped down the river was 600,000 pounds, and the amount of other articles of export was about the same as that of previous years.

River freight, exclusive of exports and Indian Department freight.

	Pounds.
Private freight	16,913,693
Government freight from Bismarck	9,036,818
Government freight from Yankton	2,595,132
Government freight from Fort Buford	661,971
Government freight from Cow Island	3,302
Government freight from Coal Banks	48,219
Government freight from Benton	48,845
Total	29,308,040

Or about 14,654 tons.

In 1881 five lines of steamboats made their headquarters at Bismarck, Dak., and 21 boats plied between that town and points on the Missouri River, making during the season of navigation from one hundred and fifty to one hundred and seventy-five trips. These boats carried into Montana 27,560,000 pounds of private and 7,200,000 pounds of Government freight, making a total of 34,760,000 pounds, valued at $5,214,000. In addition there were transported 1,300 passengers, 2,400 Indians, 1,800 head of horses and cattle, and 600 head of sheep. The exports, as far as learned, were as follows: 23,000 buffalo hides, valued at $37,500; 180 tons wool, valued at $90,000; 253,750 pounds of hides, pelts, &c., valued at about $76,125, and also an unestimated quantity of furs and wolf skins.

In 1882 the number of steamboat arrivals at Benton was 40, the number of departures from Bismarck being 86, and the number of arrivals at the same place being 85.

The total shipment of freight from Bismarck was 32,194,041 pounds, of an approximate value of $4,829,106. Of this amount, 5,100,000 pounds was Government freight, There were 3,500 passengers and 1,200 troops transported.

The exports from Benton were as follows:

Articles.	Quantity.	Value.
Wool ....pounds.	1,200,000	$300,000
Cattle ....number.	1,000	40,000
Bullion ....pounds.	129,490	63,000
Beef hides ....do..	7,600	34,000
Buffalo hides ....number.	28,000	112,000
Bales, skin ....do..	1,250	31,000
Bales, robes ....do..	3,000	24,000
Merchandise ....pounds.	44,681	8,930
Total	....	612,930

The total weight of these shipments was about 4,000,000 pounds.

The ports of entry are Benton, Mont., Poplar River, Mont., Bismarck, Dak., and Omaha, Nebr.

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COMMERCIAL STATISTICS.

Last year there were no steamboats on the Yellowstone, except those belonging to the Northern Pacific Railroad, and which were employed in carrying railroad material. It is doubtful if the Yellowstone above Glendive will ever again be of any importance as a line of transportation, unless the railroad company should exact too much. But that portion of the river from Glendive to the mouth should be improved and kept open. A navigable depth of 3½ feet at low water can be obtained and maintained during the whole boating season, thus supplying a competing water route of value.

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VII.

[Extract from Annual Report of the Chief of Engineers, United States Army, Part II, 1884.]

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., July 11, 1884.

GENERAL: I have the honor to forward herewith my annual report for the fiscal year ending July 30, 1884.

JAMES B QUINN,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. ARMY.

IMPROVEMENT OF THE MISSOURI RIVER FROM SIOUX CITY IOWA, TO FORT RENTON, MONTANA.

* * * * * * *

The steamboat business is again on the increase, a healthy down-stream and local trade rapidly developing under the influence of the rapidly increasing population of the country tributary to the river. Below Bismarck, where little if any attempt has been made to improve the river, the local trade has caused a revival of t e steamboat interest, and this interest appears to be flourishing in spite of the serious difficulties which it encounters in the snags and shifting sand-bars of this sandy portion of the river. The improvement of this portion of the river before the banks are thickly settled is very desirable, since it will be much less expensive to carry out any plan of improvement now than it will be when the question of damages to the property-holders along the banks demand consideration. In this connection I respectfully invite attention to a discussion of this subject in my last year's report, the estimates and recommendations of which are renewed.

During the season of 1883 there was transported upon the river under my charge 23,595,144 pounds of freight and an unknown number of passengers. A large percentage of this freight was Government goods and supplies.

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IMPROVEMENT OF THE YELLOWSTONE RIVER, MONTANA AND DAKOTA.

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The commerce of this river is at present insignificant, but may assume important proportions as the country tributary to it comes under cultivation. Some immediate prospects of benefits to transportation are offered in the project to ship up Missouri River freight to Glendive by railroad, and thence down the Yellowstone to Fort Buford, &c., giving a short down-stream haul to Fort Buford instead of the 300 miles of up-stream haul from Bismarck, as at present.

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APPENDIX B.

ANNUAL REPORT OF CAPTAIN JAMES B. QUINN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., August 21, 1886.

SIR: In response to your telegram of the 18th inst., I have the honor to inclose herewith the report of operations upon the improvement of the Missouri River between Sioux City, Iowa, and Fort Benton, Mont., for the fiscal year ending June 30, 1886.

Very respectfully, your obedient servant,

JAMES B. QUINN,
Captain of Engineers.

Maj. CHAS. R. SUTER,
President Missouri River Commission.

REPORT OF OPERATIONS FOR IMPROVING THE MISSOURI RIVER FROM SIOUX CITY, IOWA, TO FORT BENTON, MONT., FOR THE FISCAL YEAR ENDING JUNE 30, 1886.

The working party which had been left at Two-Calf Island, early in 1885, had accumulated a large quantity of brush and other dam-building material by the arrival of the steamer Josephine, July 3, but this party was not moved up to the head of Grand Island, the site of the proposed dam, till the 26th of July. By the 10th of August the dam at the head of Grand Island was finished. This dam is 660′ long and required for its construction a large amount of material, viz, 850 fascines, 725 poles and stakes, and 830 cubic yards of rock and gravel ballast.

As soon as this dam was finished the party crossed over to the head of Hammond Island and, shortly after, finished the dam at this point. This dam is 350′ long and required in its construction 1,700 fascines, 1,450 poles and stakes, and 1,660 cubic yards of rock and gravel ballast.

Through the agency of these two constructions the difficult crossing at Grand Island has been entirely remedied.

As soon as these two dams were finished the working parties were moved up to Duphins Rapids, and the reconstruction of the dams at this difficult place commenced.

The main dam at this place is 1,127′ long, and, at its outer extremity, is joined to a wing which extends down stream a distance of 560′. About 600′ above the main dam a relief dam 612′ long was built parallel with the main dam.

In the construction of these dams there was used 3,900 fascines and 1,850 cubic yards of rock and gravel ballast.

The completion of the dams at this point has very materially improved the navigation, as it was a very difficult place, not only on account of the shoal waters, but also for the swiftness of the current. Heretofore all the dams constructed at this place have been destroyed by the ice or high water, and it is, therefore, with no little pride that I am now able to state that the dams recently built at this place have successfully withstood the onslaught of the ice and high water and are now in as good condition as when finished. To those unacquainted with the location the significance of the above statement may not be fully appreciated otherwise than a complete vindication of the employés engaged upon the work, as to the untruthfulness and malignant assertions of envious and carping critics, but, aside from this, it appears to be proven that the form of construction adopted in these dams is the best adapted to meet the requirements of future similar work. It is a matter of serious regret that suitable material for such dams is becoming very scarce and will have to be transported long distances. As a consequence such constructions must rapidly increase in

cost, and it was in partial anticipation of this that the acquisition of a powerful dredge boat was urged.

During the season 3,309 lineal feet of dam was constructed at an average cost of $9.07 per lineal foot. Considering the very substantial character of the constructions this is a very reasonable price, and it is hardly likely that it can be improved upon in any future work of this description.

The steamer Josephine, owing to the lack of any appropriation for snagging, was used as a transport and tow-boat. And from estimates based upon some similar work, done by the Fort Benton Transportation Company, her possession by the Government resulted in a saving to the work of something near $30,000. The original cost of the steamer was $13,200, and consequently, she apparently more than paid for herself in one season.

While she is thoroughly fitted for the duty for which she was bought, she is entirely too large for economical towing, about the works, and a small tow-boat is essential for the economical prosecution of the work.

The Josephine can be used for the transportation of materials and supplies at the commencement of the season and afterwards attend to her special duties of snag pulling.

The tow-boat would, therefore, be solely for use as a tow-boat, and should be equipped with powerful machinery and be of small size.

The narrowness of the channel in the rocky portion of the river subjects the larger boats to a very severe service during the working season, and in consequence the steamer Josephine will need some repairs to enable her to resume work. She was hauled out on the bank to protect her from the outgoing ice during the spring break-up, and through the absence of funds, to put her in commission, she was left on the blocking until the rapid cutting of the bank made it necessary to launch her.

The steam dredge-boat was completed on the 2d of September and proved to be an excellent machine. During the short experimental working of the machine it averaged 1,500 cubic yards per day, and will, undoubtedly, be able to excavate considerably more than this per day, when working regularly. As it was finished too late in the season to begin any extensive work, it was merely employed in excavating a small experimental channel through the bar immediately below Fort Benton, the material removed being used to form a small temporary dam. As the result of this work a four-foot channel through the bar was obtained, and, at last accounts, this depth was still maintained, the ice having simply leveled the earthen dam, as was expected.

Upon the suspension of work the dredge and a barge were laid up for the winter in a harbor dredged out for the purpose. The remainder of the floating plant was hauled out, beyond danger, where it still remains, with the exception of the steamer Josephine, before alluded to.

Plans for a pair of improved compound non-condensing engines, for the steamer Josephine, have been prepared in the event of its becoming necessary to substitute new engines for the present old-style high-pressure engines. Plans have also been nearly completed for the small tow-boat.

All of the past season's work has been confined to that portion of the river between Fort Benton and Carroll, Mont. It is difficult to get any definite information concerning the extent of the commerce over this portion of the river, as the only line of boats upon this portion of the river is owned by a single firm, who appear to be afraid to furnish any statistics of their trade, for the reason, as they expressed it, "that it would be used against them." I have no information from them upon this subject, but from an estimate made from the number of trips made by their boats during the season, as given by my recorders at the works, there was probably something like 13,500,000 pounds of freight carried by the four boats during the season.

Of this amount, probably 1,000,000 pounds was wool, shipped down-stream. Besides the wool there was considerable grain, flour, hides, and bullion shipped downstream, of which I can give no estimate. Although the down-stream traffic does not amount to half of that in the opposite direction, I believe it would show a healthy increase from year to year if the data was accessible.

Between Bismarck and Fort Benton the local traffic is on the increase, but is much retarded in consequence of the greater portion of the bordering country being Indian reservations, and, practically, non-productive.

Below Bismarck the local traffic is improving, and several small boats find profitable occupation. The General Terry and General Tompkins are running in this portion of the river, but I am not in possession of any information as to the extent of the commerce carried.

The country is being gradually settled up, and, in the event of the Indian reservations being opened up for settlement, the commerce of this portion of the river will be speedily increased.

Nothing has been done on this stretch of river between Bismarck, Dak., and Sioux City, Iowa, for some time, and although it is possible to apply the system of improve-

ment advocated by me for the improvement of the sandy portion of the upper river, I do not think that, for the present, there is much more improvements required here than will result from the pulling of the dangerous snags.

PROJECT FOR NEXT SEASON'S OPERATIONS.

The dredging should be continued and, in connection with it, the construction of dams, when necessary, to further control the water and maintain it in the desired channel.

The snag pulling is very necessary, and should embrace the whole of the river between Sioux City, Iowa, and Carroll.

As the rectification of the channel in the sandy portion of the river is becoming necessary with the advance of the improvement, the application as an experiment to a characteristic section, should be provided for.

With the addition of a suitable tow-boat it is believed the plant will be in such condition that the greater portion of the work can be done by contract.

Estimates.

Dredge operations, including repairs	$30,000 00
Snag-boat operations, including repairs	25,000 00
Tow-boat operations, including repairs	15,000 00
Dam-building operations	30,000 00
Experimental works for rectification of channel, including plant	32,000 00
Office and inspection expenses and surveys	20,000 00
Care and preservation of plant, and contingent expenses	8,000 00
Total	160,000 00

Money statement.

July 1, 1885, amount available		$43,958 21
July 1, 1886, amount expended during fiscal year exclusive of outstanding liabilities, July 1, 1885	$42,866 83	
July 1, 1886, outstanding liabilities	1,091 38	
		43,958 21

Amount (estimated) required for completion of existing project	not determined.
Amount that can be profitably expended in fiscal year ending June 30, 1888	160,000 00
Submitted in compliance with requirements of section 2 of river and harbor acts of 1866 and 1867.	
Total expended upon the present project to June 30, 1886	201,456 57

Abstract of appropriations.

By act of Congress approved August 14, 1876	$20,000 00
By act of Congress approved June 18, 1878	30,000 00
By act of Congress approved March 3, 1879	45,000 00
By act of Congress approved June 14, 1880	25,000 00
By act of Congress approved March 3, 1881	40,000 00
By act of Congress approved August 2, 1882	100,000 00
By act of Congress approved July 5, 1884	*125,000 00
Total	385,000 00

* Thirty thousand dollars of this amount was expended by Missouri River Commission.

The following table gives the cost, capacity, &c., of boats navigating the Missouri River between Sioux City, Iowa, and Fort Benton, Mont., in 1885–'86.

Names.	Cost.	Horse-power.	Custom-house tonnage.	Tonnage on 3 feet draught.	Tonnage on 2 feet draught.	Tonnage to the inch.	Remarks.
Benton*	$25,000 00	325.42	394.08	181.9	55	14.0	
Helena*	22,500 00	244.42	352.31	205.5	70	13.5	
Rosebud*	20,000 00	283.48	286.49	182.1	75	11.9	
Batchelor*	18,500 00	244.42	313.00	195.6	90	11.9	
Milwaukee†	....	....	....	....	....	....	No record.
Judith†	....	....	....	....	....	....	Do.
General Tompkins†	....	....	....	....	....	....	Do.
General Terry†	16,000 00	239.96	323.15	186.0	75	11.5	
Josephine	19,000 00	325.42	300.51	180.7	70	12.3	Government.
Eclipse	10,000 00	258.80	295.98	182.1	75	11.9	

* Between Bismarck and Fort Benton.
† Between Sioux City and Bismarck.
‡ Formerly Union Pacific Railroad transfer boat.

Several smaller boats also navigated the river, the names of which have not been learned.

The following table gives the (estimated) business of 4 boats in 1885:

Names.	Number round trips.	Tons carried each trip.		Total tons.	Total number pounds.
		Up-stream.	Down-stream.		
...helor	5	300	150	2,250	4,500,000
...na	4	300	150	1,800	3,600,000
...nton	3	300	150	1,350	2,700,000
Rosebud	3	300	150	1,350	2,700,000
Total	15	300	150	6,750	13,500,000

Z Z 2.

REPORTS OF THE MISSOURI RIVER COMMISSION RESPECTING ALLOTMENT OF APPROPRIATION OF AUGUST 5, 1886.

1.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., September 2, 1886.

SIR: At a meeting of the Missouri River Commission, held on August 26 and 27, the subject of the expenditure of the item of $375,000 for improving Missouri River from its mouth to Sioux City, in the river and harbor bill approved August 5, 1886, was carefully considered. According to the wording of the act the money is to be expended in "continuing improvement, including necessary work at Omaha, Atchison, Saint Joseph, Fort Leavenworth Reservation, Arrow Rock, Kansas City, Plattsmouth, Brownsville, and Nebraska City, under the direction of the Secretary of War, in accordance with plans and estimates to be furnished by the Missouri River Commission."

In their last annual report the Commission submitted an estimate of $1,000,000 for continuing the improvement of the river from Kansas City down, this estimate including the continuation of work then in progress at Kansas City and Saint Joseph, two of the places specially mentioned in the above-quoted act. As regards the other places mentioned but little is actually known. Reports and plans and estimates for work of improvement have been made for all of them in former years, and at all except Arrow Rock work on a small scale has been executed. From the best information available the Commission infer that but little if any trace of such work is now to be found. The cause of such failure is to be sought in the utterly insufficient appropriations which were made from year to year, and which never allowed work to be done of an extent and character which would insure permanence or efficiency. From these old reports and maps the Commission infer that to do the necessary work at the various points enumerated in the act, exclusive of Saint Joseph and Kansas City, would require from $1,000,000 to $1,500,000, besides a large addition to the present plant amounting to probably $300,000 more. During the past season the greater portion of the plant was concentrated on the work at Kansas City; the balance was employed at Saint Joseph. Even this division of the plant was attended with serious drawbacks, and any further division would, in the opinion of the Commission, render work impracticable.

To scatter the current appropriation in allotments to all the points enumerated in the bill would result in no good whatever, as the amounts would be everywhere inadequate to even begin the work needed. Under these circumstances the Commission deem that a literal compliance with the requirements of the act is impossible, and they have therefore decided to recommend the continuance of work at Kansas City and Saint Joseph, two of the places enumerated, and on the general improvement of the river in the vicinity of Kansas City. At these points a good deal of work was done last year which needs extension and completion. With the funds now available this can be done, and reasonable progress be made toward completion of the local projects. As regards the other points mentioned, the Commission propose to make, at once, such surveys as are needed, and to submit plans and estimates in time for the action of Congress at its next session.

The following allotments from the appropriation of $375,000 for improving Missouri River from its mouth to Sioux City (act approved August 5, 1886), have been made by the Commission, and your approval of the same is requested.

For continuing improvement in vicinity of Kansas City, Mo	$260,000
For continuing improvement in vicinity of Saint Joseph, Mo	75,000
For special surveys (at Omaha, Atchison, Fort Leavenworth Reservation, Arrow Rock, Plattsmouth, Brownsville, and Nebraska City)	10,000
For construction of plant	30,000
Total	375,000

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers, U. S. A.,
President Missouri River Commission.

The SECRETARY OF WAR,
(Through the Chief of Engineers, U. S. A.)

[First indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
September 10, 1886.

Respectfully submitted to the Secretary of War, recommended for approval.

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
In Charge of Office.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
October 11, 1886.

Respectfully returned to the Secretary of War.

The river and harbor act approved August 5, 1886, provides as follows:

Improving Missouri River from its mouth to Sioux City: Continuing improvement, including necessary work at Omaha, Atchison, Saint Joseph, Fort Leavenworth Reservation, Arrow Rock, Kansas City, Plattsmouth, Brownsville, and Nebraska City, three hundred and seventy-five thousand dollars; to be expended under the direction of the Secretary of War, in accordance with plans and estimates to be furnished by the Missouri River Commission.

It will appear from the within letter that the proposed allotment of the above-mentioned appropriation by the Missouri River Commission does not contemplate any improvement at Omaha, Atchison, Fort Leavenworth Reservation, Arrow Rock, Plattsmouth, Brownsville, and Nebraska City, as provided for in the act, but recommends that special surveys be made at these localities, costing, in the aggregate, $10,000. To this proposed disposition of the funds Senators Plumb and Ingalls, of Kansas, and Senator Van Wyck, of Nebraska, and others, protest in vigorous terms, for the reason that such action upon the part of the Commission is contrary to the plain provisions of the act, and in violation of the intentions of its framers at the time of its passage. The views of these gentlemen are sustained by the Hon. E. N. Morrill and the Board of Trade of Leavenworth, Kans., while those of the Commission are concurred in by the Hon. William Warner, M. C., and the Board of Trade of Kansas City.

The above protests, etc., having been referred to the Missouri River Commission, have been returned to this office by the President of the Commission, Maj. C. R. Suter, Corps of Engineers, whose report thereon, dated October 6, 1886, herewith submitted, is commended for consideration.

In the opinion of this office the views of the Commission are based upon sound principles, and its recommendations are believed to be for the best interests of the improvement. It would evidently be necessary that some plans for the improvements at the localities designated in the act be decided upon before undertaking work, and such plans can only be properly designed upon the results to be derived from careful surveys. On the other hand, the terms of the act are specific, and it is questionable whether, upon the statements made by Senators Plumb and Van Wyck, any deviation from its plain requirements would be permissible.

The subject is respectfully submitted for decision of higher authority.

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.,
In Charge of Office.

[Third indorsement.]

WAR DEPARTMENT, *October* 28, 1886.

The allotments as made by the Commission are approved.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
November 1, 1886.

Respectfully returned to Maj. C. R. Suter, Corps of Engineers, President Missouri River Commission, inviting attention to the foregoing indorsements, by which he will be guided.

After such record as may be necessary has been made it is desired that this paper be returned to this office.

By command of Brig. Gen. Duane.

JOHN G. PARKE,
Colonel of Engineers,
Bvt. Maj. Gen., U. S. A.

[Fifth indorsement.]

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., November 4, 1886.

Respectfully returned to the Chief of Engineers, U. S. Army, as directed, necessary record having been made.

CHAS. R. SUTER,
Major of Engineers, U. S. A.,
President Missouri River Commission.

2.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., October 6, 1886.

COLONEL: I beg leave to return, herewith, certain papers referred to me for report by your indorsement, viz, letter of Hon. P. B. Plumb, of

September 9, 1886; letter of Board of Trade of Leavenworth, by H. Miles Moore, secretary, of September 13, 1886; letter of Hon. John J. Ingalls, of September 14, 1886; letter of Hon. E. N. Morrill, of September 17, 1886, and letter of Hon. C. H. Van Wyck, of September 18, 1886. These letters all concur in recommending to the Secretary of War to disregard the recommendations of the Missouri River Commission in allotting the appropriation for "Improving the Missouri River from its mouth to Sioux City, Iowa," made by act approved August 5, 1886, it being alleged, in some cases, that the recommendations of the Commission are in violation of the statute.

In my letter of September 2, transmitting the recommendations of the Commission to the Secretary of War, the views of the Commission were set forth at length. I will only add now such information as seems necessary to meet the points raised in these various letters. To fully understand the situation it is necessary to refer to the plans and recommendations heretofore submitted to Congress by the Commission, upon which the current appropriation is presumably based. The Commission, being by law specifically organized for the improvement of the navigation of the river, have, from the beginning, taken the ground that their action and recommendation should of necessity be confined to that point alone, till Congress, having all the facts before them, should decide and direct otherwise. Hence all the recommendations heretofore made by the Commission, and the estimates submitted by them, have been for the continuous improvement of the river down-stream from a point in the vicinity of Kansas City, Mo. The plans of the Commission only included work at one other point, Saint Joseph, Mo., where, for reasons specified in their first report, work was deemed advisable and has been carried on by the Commission. The Commission have taken the same position, in this respect, as that held by the Mississippi River Commission, hence the legislation affecting this latter body may be taken as a precedent in deciding as to the intent of recent Congressional action affecting the Missouri River improvement. In the appropriation for the Lower Mississippi River, act approved July 5, 1884, the act directs that a certain gross sum shall be expended on the improvement of the Lower Mississippi, "including the improvement and preservation of the harbors of New Orleans, Natchez, Vicksburg, Greenville, Memphis, Hickman, and Columbus, the deflection of the waters of Red River from the Atchafalaya, and keeping open a navigable channel through the mouth of the Red River into the Mississippi River;" no specific allotments being made for these special works. The Mississippi River Commission took the ground that this was work for which no estimates had been before Congress, and that it was merely intended to recognize such work and to authorize the Commission to carry it out. They, therefore, made no attempt to begin work at any of the places designated, but sent in plans and estimates with their next annual report. No criticism was ever made, to my knowledge, on this action of the Commission, and Congress was apparently satisfied, for, in the current river and harbor bill certain of these places—not all—are specifically designated and sums allotted for their improvement. As the wording of the act of 1884 in regard to the Lower Mississippi is practically identical with that of the act of 1885 in regard to the Missouri, the Missouri River Commission felt perfectly justified in assuming that the intention of Congress in their case was to recognize this local work and provide for plans and estimates being submitted to them for future action.

Further practical reasons which guided the Commission in their action are set forth in my letter of September 2 to the honorable Secre-

tary of War. The estimates of the Commission for carrying on the improvement of the navigation of the river were $1,000,000. This was cut down by the Committee on Rivers and Harbors to $500,000, and subsequently, in the general scaling of the appropriation by the Senate, was reduced to $375,000; but little more than a third of the estimate for carrying on the work contemplated by the Commission and ordered by the act itself. In addition to this, work was directed at seven special localities, for which no plans or estimates existed. The Commission, from such data as they could obtain, estimated that this local work would require from $1,000,000 to $1,500,000, with an addition for new plant amounting to $300,000 more. The experience on the Missouri River for the last ten years has shown conclusively that any attempt at doing work without sufficient means to carry it to completion in a single season is only to invite disaster, and that there are few, if any, places where work could safely be begun with less than from $200,000 to $300,000. Any attempt to scatter the appropriation in small sums to the various points designated would render work at any point impossible, unless it were carried out with a reckless disregard of the risk of failure, which all previous experience would show to be almost certain. It seemed, therefore, obvious to the Commission that some choice would have to be made among the various points designated in the act. On the one hand were seven localities about which nothing was definitely known, except that any one of them would probably absorb the whole appropriation. Moreover, to make surveys and prepare plans for these places would probably require the whole period available for work this fall. On the other hand, two of the designated points (Kansas City and Saint Joseph) were well known; plans for immediate use were ready and the plant was on the ground. Large expenditures had been made at both places, and the works were well advanced, and only required extension and completion. Both points were considered as in the direct line of improvement of navigation ordered by the act and the local and commercial interests of both places, especially Kansas City, are equal to or greater than any other points on the river. Under these circumstances there could be no doubt as to the proper course of the Commission to pursue, and their recommendations were made accordingly. It is proper to add here that the allotment for Saint Joseph is absolutely necessary to secure the work of last year, which could not, for want of funds, be extended sufficiently to secure its safety. At Kansas City, in addition to the great local interests requiring protection, changes in the river channel, which occurred last spring, must be met, or Kansas City bridge will be the head of navigation on the Missouri. This work must not only be done, but be done promptly, as the season for possible work is nearly ended.

The other allotments recommended by the Commission were for making special surveys at the points designated in the act, to enable them to prepare the plans and estimates required by the law, and for the construction of more barges, which are very urgently needed.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers, U. S. A.,
President Missouri River Commission.

Col. JOHN G. PARKE,
In Charge of Office Chief of Engineers, U. S. A.

Z Z 3.

ANNUAL REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., August 2, 1887.

SIR: The Missouri River Commission beg leave to submit herewith their annual report upon the operations in their charge for the fiscal year ending June 30, 1887.

SURVEYS.

Work under this head was carried on by allotments from the appropriation for improvement, there being no specific appropriation for the purpose.

Secondary triangulation was carried from Fort Leavenworth, Kans., to Glasgow, Mo., and from Tavern Rock, Mo., to Saint Louis, Mo., a total distance of 240 miles. Permanent bench-marks and levels were carried from Fort Leavenworth, Kans., to Berlin, Mo., 108 miles. In the office all computations affecting the triangulation have been carried out and a large amount of physical data prepared for publication.

To complete the survey of Missouri River there still remains to carry the triangulation from Fort Leavenworth, Kans., to Trovers Point, Mont., 1,520 miles; permanent bench-marks and levels over the same distance, and also from Berlin to the mouth of the river, a total distance of 1,652 miles. Topography and hydrography are required from Fort Pierre to Fort Benton, 1,100 miles.

This work is of great and permanent importance, and the Commission earnestly hope that Congress will allow them funds enough to justify more rapid progress than has been possible heretofore. The Commission are also of the opinion that this work should be provided for by specific appropriation, and not made a charge against the appropriation for improvement as is now necessarily the case.

For details of work done reference is made to the report of the secretary of the Commission and its appendices.

CONSTRUCTION.

Under this head work has been carried on in the vicinity of Kansas City and Saint Joseph, Mo. Last season the plant was repaired and everything got ready for work, but the late date at which the appropriation became available rendered it necessary to defer operations till this spring, when work began at both places. At Saint Joseph 4,158 linear feet of bank in Bon Ton Bend have been revetted, this work being a continuation of the work of 1885. There still remain about 2,000 feet to complete this work, which the Commission have not at present funds to undertake.

At Kansas City the Commission have begun and nearly finished the revetment of the right bank at the East Bottoms, immediately below Kansas City, and have also built a pile dike across the head of a slough above this work. During the rest of the season it is expected to complete the revetment of East Bottoms and also that of Little Platte Bend at the head of the work above Parkville. The failure this year of the river and harbor bill has very seriously embarrassed the work. The rectification works in Kaw Bend and the protection of Sharp's Bend below Randolph, work which had been completed for this season, is

of necessity postponed till another year. The work executed in this vicinity in former years has given good satisfaction. Some slight repairs have been needed on the Kaw Bend work, but they were not at all serious in character and can probably be avoided in future.

For details of this work see report of the president of the Commission and appendices.

PLANT.

During the year one steam tow-boat has been purchased for the use of the work, and fifteen barges are now in process of construction.

SPECIAL SURVEYS.

The river and harbor act of August 5, 1886, provided for carrying on the work under the Commission in the following language: "Improving Missouri River from its mouth to Sioux City: Continuing improvement, including necessary work at Omaha, Atchison, Saint Joseph, Fort Leavenworth Reservation, Arrow Rock, Kansas City, Plattsmouth, Brownville, and Nebrasda City, $375,000; to be expended under the direction of the Secretary of War in accordance with plans and estimates to be furnished by the Missouri River Commission."

In their last annual report, dated November 17, 1886, the Commission explained at length the reasons which forced them to interpret the words "necessary work" as used in the law with reference to a majority of these places to mean the necessary preliminary work, such as must always precede the inauguration of any important engineering enterprise. This preliminary work is the making of a survey, the preparation of a plan, and an estimate of its cost.

At two of the places named in the law, Kansas City and Saint Joseph, works of construction were already in progress, and no further preliminaries were required. The reasons for continuing the work of construction at these two places and limiting the work at the seven other places enumerated to a survey and estimate were fully given in the report above referred to. Since the date of that report the surveys have been made. The maps and estimates of the funds required for the "necessary work" at each locality are herewith transmitted. (Appendix C).

As has been explained by the Commission in former reports, no benefit to the navigation interest is to be expected from work executed at detached points along the river. The protection of a caving bank, unless made part of a comprehensive scheme, may or may not be useful to navigation. If work of this kind be done at points so far separated that it will be impossible for a general improvement of the river to embrace all of such points within a reasonable length of time, it is certain that some, if not all, of the works will be useless to the navigation interest. If work be undertaken now at the places referred to it will have for its object the protection of local interests alone.

The results of recent work upon the river are such as to encourage the belief that the improvement of the channel is physically practicable. But there are no data for estimating what its final cost will be. The Commission have, ever since their creation, urged the policy of carrying on the work in a systematic manner with annual appropriations, moderate in comparison to the results hoped for and to their total cost, yet liberal enough to enable the required data as to cost to be obtained with accuracy. In their best judgment the sum of $1,000,000

per year should be employed in that manner. It is not yet certain whether the improvement can be accomplished at a cost that is not prohibitory, even if conducted with one distinct object in view, unhampered by the demands of local interests. If local interests are to control the distribution of the funds, and the work is to begin at a large number of widely separated points, all doubt is removed and the question is decided in the negative. The ground taken by the Commission upon the subject in their first report has been confirmed by all of their subsequent observations and reflection. They are convinced that if the funds be distributed among numerous detached points, as now seems to be contemplated, vast sums of money and many years of time may be consumed without conferring any appreciable benefit upon the commerce of the river.

Full details on this subject are given in report of secretary of Commission on special surveys hereto appended, marked Appendix C.

RAILROAD DIKE AT CAMDEN.

Complaint having been made to the Commission that a dike in process of construction by the Wabash Western Railroad near Camden, Mo., was a serious obstruction to navigation, an examination and subsequently a survey of the locality were ordered. The obstruction complained of by the steam-boat men proved to be a very serious one. In compliance with section 4 of the river and harbor act, approved August 5, 1886, a copy of the report of the secretary of the Commission on this matter was forwarded to you direct, and this report is repeated here. (See Appendix D.)

RECOMMENDATIONS.

The Commission renew their recommendation that at least $1,000,000 be appropriated for continuing the improvement of the river, in addition to any sums which Congress may see fit to devote to work at special localities. With a less sum than this it will be many years before the work will cover a sufficient extent of river to enable a proper estimate to be formed as to its cost and its value to the country. No engineering difficulty has as yet presented itself to suggest any doubt as to the possibility of carrying it to successful completion.

For continuing the survey of the Missouri River; for the examinations and observations required in a thorough study of the problem confided to them, and for salaries, traveling, and office expenses, the Commission recommend an appropriation of $150,000. They also renew their previous recommendation that the $15,000 appropriated for a survey of the Missouri River above the Missouri River Falls, at Fort Benton, be made available for the general survey of the river.

The recommendations of the Commission for the year ending June 30, 1889, are recapitulated as follows:

(1) Appropriation for the improvement of Missouri River from its mouth to Sioux City	$1,000,000
(2) Appropriation for surveys and examinations	120,000
(3) Appropriation for office and traveling expenses and salaries of commissioners	30,000
(4) Reappropriation for general survey of Missouri River of the item of $15,000 appropriated in the act of July 5, 1884, for survey of river above the falls	15,000

Estimates for work at special localities designated in river and harbor act approved August 5, 1886.

Localities.	Total estimated cost of project.	Time required to complete.	Amount required for first year.
Omaha, Nebr	$1,230,600	3 years.	$690,000
Plattsmouth, Nebr	675,600	1 year.	675,600
Nebraska City	645,100	1 year.	645,100
Brownsville	708,900	2 years.	478,650
Saint Joseph	691,400	2 years.	536,100
Atchison	777,400	2 years.	512,960
Fort Leavenworth	618,600	1 year.	618,600
Kansas City	657,400	2 years.	224,910
Arrow Rock	339,400	1 year.	339,400

Money statement.

Available July 1, 1886, and received since to June 30, 1887:			
Appropriation for survey of Missouri River from its mouth to Fort Benton, Mont., act of August 2, 1882			$2,506.63
Appropriation for improving Missouri River from its mouth to Sioux City, Iowa, act of July 5, 1884			75,538.50
Appropriation for improving Missouri River from Sioux City, Iowa, to Fort Benton, Mont., act of July 5, 1884			4.57
Appropriation for a survey of the Missouri River above the Missouri River Falls, at Fort Benton, act of July 5, 1884			15,000.00
Appropriation for improving Missouri River from its mouth to Sioux City, etc., act of August 5, 1886			375,000.00
Cash received from sales of fuel to officers			238.44
Total			468,288.14
Expended from July 1, 1886, to June 30, 1887, exclusive of outstanding liabilities July 1, 1886:			
By Maj. W. R. Livermore, Corps of Engineers		$60,343.26	
By the president of the Commission		143,709.59	
By the secretary of the Commission		53,328.42	
Outstanding liabilities July 1, 1887:			
Of the president of the Commission	$31,575.05		
Of the secretary of the Commission	93.26		
		31,668.31	
			289,049.58
Balance			179,238.56
Deduct amount reserved for disbursement in office Chief of Engineers, U. S. Army			1,242.70
Balance available July 1, 1887			177,995.86

Respectfully submitted.

CHAS. R. SUTER,
Lieut. Col. of Engineers,
President Missouri River Commission.
A. MACKENZIE,
Major of Engineers.
O. H. ERNST,
Major of Engineers.
G. C. BROADHEAD.
WILLIAM J. BROATCH.

Hon. WILLIAM C. ENDICOTT,
Secretary of War.
(Through Chief of Engineers, U. S. A.)

Financial statement from July 1, 1886, to June 30, 1887.

Work.	Resources.							Expenditures and transfers.				
	Amount available July 1, 1886, of appropriation, act August 2, 1882.	Amount available July 1, 1886, of appropriations, act of July 5, 1884.		Received by transfer from other allotments.	Allotments from appropriation, act of August 5, 1886.	Received from sales of fuel and from Lieutenant Fisk.	Total.	Transferred to other allotments.	Amount expended during fiscal year, exclusive of outstanding liabilities, July 1, 1886.	Outstanding liabilities June 30, 1887.	Total expended and transferred.	Amount available July 1, 1887.
		Allotments.	Unallotted.									
In charge of Secretary.												
Survey of Missouri River from its mouth to Fort Benton, Mont.	$2,506.63						$2,506.63		$2,506.63		$2,506.63	
Improving Missouri River from its mouth to Sioux City, Iowa:												
Office and traveling expenses and salaries of Commission		$761.68		$25,000		$182.96	25,944.64		12,735.56	$75.93	12,811.49	$13,133.15
Surveys and permanent bench-marks		502.72		23,000			23,502.72		22,883.78		22,883.78	618.94
Care of plant, river gauges, physical data		1,440.33		12,000			13,440.33		7,703.62	17.33	7,720.95	5,719.38
Tow-boat		23,900.00					23,900.00	$23,900			23,900.00	
Special surveys					$10,000		10,000.00		7,494.26		7,494.26	2,505.74
Improving Missouri River from Sioux City, Iowa, to Fort Benton, Mont.:												
Office and Commission expenses		1.57				3.00	4.57		4.57		4.57	
In charge of Maj. W. R. Livermore, Corps of Engineers, to November 6, 1886, and the president of the Commission since November 7, 1887.												
Improving Missouri River from its mouth to Sioux City:												
Kansas City		46,822.38			260,000	42.36	306,864.74	36,100	126,826.03	18,482.42	181,408.45	125,456.29
Saint Joseph		2,111.39			75,000	13.12	77,124.51		57,290.35	10,992.63	68,282.98	8,841.53
Construction of plant					30,000		30,000.00		21,179.17	2,100.00	23,279.17	6,720.83
Unallotted.												
Survey of Missouri River above the Missouri River Falls at Fort Benton			$15,000				15,000.00					15,000.00
Total	2,506.63	75,540.07	15,000	60,000	375,000	241.44	528,288.14	60,000	258,623.97	31,668.31	350,292.28	177,995.86

List of civilian engineers employed on work of river and harbor improvements in charge of Missouri River Commission from November 1, 1886, to June 30, 1887, inclusive, under the river and harbor appropriation act approved August 5, 1886.

[Improving Missouri River from its mouth to Sioux City.]

Name and place of residence.	Time employed. Mos.	Time employed. Dys.	Compensation per month.	Where employed.
A. H. Blaisdell, Saint Louis, Mo	7	0	$200.00	Saint Louis, Mo.
Samuel H. Yonge, Kansas City, Mo	8	0	200.00	Kansas City, Mo.
S. Waters Fox, Saint Joseph, Mo	8	0	200.00	Saint Joseph, Mo.
B. C. Thayer, Saint Joseph, Mo	8	0	125.00	Do.
A. H. Weber, Kansas City, Mo	1 3	20 0	100.00 125.00	Kansas City, Mo.
R. H. Bacot, Kansas City, Mo	8	0	125.00	Do.
Ed. F. Hermanns, Kansas City, Mo	4	0	125.00	Do.
* Wynkoop Kiersted, jr., Omaha, Nebr	1 6	11 6	125.00 170.00	In vicinity of Omaha, Plattsmouth, Nebraska City, Brownville, and Arrow Rock.
* G. T. Nelles, Leavenworth, Kans	2 2	0 9	125.00 170.00	In vicinity of Atchison and Fort Leavenworth.
* D. C. Humphreys, Saint Louis, Mo	0	10	150.00	Saint Louis, Mo.
* O. W. Ferguson, Saint Louis, Mo	3	13	100.00	In vicinity of Omaha, Plattsmouth, Nebraska City, Brownville, and Arrow Rock.
* T. C. Hughes, Wichita, Kans	2	11	130.00	Kansas City, Mo.
* William Runge, Kansas City, Mo	0	7	130.00	Do.
* Elisha Diefendorf, Leavenworth, Kans.	1	4	130.00	In vicinity of Atchison and Fort Leavenworth.
* T. W. Bowman, Kansas City, Mo	0	13	130.00	Do.
* H. W. Kerr, Leavenworth, Kans	0 1	10 17	100.00 130.00	Do.
* J. C. Meredith, Saint Joseph, Mo	0	13½	100.00	Saint Joseph, Mo.
* E. C. Jones, Leavenworth, Kans	0	3	100.00	In vicinity of Atchison and Fort Leavenworth.
* T. C. Thomas, Chicago, Ill	0	12	100.00	Kansas City, Mo.

* On special surveys.

APPENDIX A.

ANNUAL REPORT OF SECRETARY MISSOURI RIVER COMMISSION, 1886–'87.

ST. LOUIS, MO., *July* 30, 1887.

SIR: I have the honor to submit the following annual report of the work in charge of the Secretary of the Commission for the fiscal year ending June 30, 1887.

SURVEYS.

In July, 1886, a small office force, under Mr. O. B. Wheeler, was at work on the reduction of secondary triangulation between Glasgow, Mo., and Tavern Rock, Mo., made in the winter of 1884–'85. Funds were exhausted at the end of the month and the force was discharged. The river and harbor bill of August 5, 1886, enabled work to be resumed August 9. Work in the office continued until September 29, when parties left for work in the field. Meanwhile the Commission, at its meeting August 26, 1886, had recommended an allotment of $23,000 for the prosecution of surveys, which action was approved by the Honorable Secretary of War, October 28, 1886.

Field work was resumed at Fort Leavenworth whose latitude and longitude were known. The party was organized as follows, quartered on three-quarter boats:

Reconnoitering and △ station building party—One quarter-boat.

Employés.	Compensation per month.	Employés.	Compensation per month.
Reconnoitering:		Crew—Continued.	
1 assistant engineer (in charge)	$200	1 watchman	$30
1 rodman	30	1 cook	45
1 boat and axman	40	1 cook	15
△ building:		Crew of launch:	
1 assistant engineer	100	1 pilot	100
1 foreman	45	1 engineer	100
4 axmen	30	1 fireman	45
Crew:		1 deck hand	30
1 mate	50		

Observing party—One quarter-boat.

Right bank:		Left bank—Continued.	
1 assistant engineer	$125	1 recorder	$40
1 recorder	90	3 axmen	30
1 recorder	40	Crew:	
3 axmen	30	1 mate	50
Left bank:		1 cook	45
1 assistant engineer	100	1 cook	15
1 recorder	90		

Permanent bench-mark party—One quarter-boat.

Permanent bench-mark party:		Two level parties (each)—Continued.	
1 assistant engineer (in charge)	$200	1 boatman	$30
1 rodman	30	Crew:	
1 flagman	40	1 mate	50
5 laborers	30	1 watchman	30
Two level parties (each):		3 boatmen	30
1 assistant engineer	100	1 cook	45
1 rodman	40	1 cook	15
1 axman	30	1 laundress	15
1 shademan	30		

The river closed early in December and the triangulation parties were then transported in wagons, reaching Glasgow before Christmas. When ice closed the river the P. B. M. party was disbanded, excepting two retained for office work.

In January a small party was left in the field to complete triangulation from Tavern Rock to the mouth of the river, and a computing force began work in the office. In March the field work was finished and the computing force doubled, and it has completed its work.

The secondary triangulation is now completed from Fort Leavenworth to Saint Louis. Tabulation of final results and plot of triangulation are appended. For details of methods of field work, base measurement, computation, etc., reference is respectfully made to Appendix A, Annual Report of the Commission for 1886. The work rests on the following data:

	Length.	Log.	Azimuth.			Elevation above sea.
	Meters.	*Meters.*	°	′	″	*Feet.*
Glasgow base: △ East to △ West base:						
Measured or observed	2,414.94		112	34	49.75	625
Beverly base: △ Northeast base to △ Southwest base:						
Measured or observed	2,418.11	3.3834767	48	13	27.54	768.8
Computed from Glasgow base		3.3834462	48	13	18.97	
Difference		0.0000305			8.57	

Details of Beverly base measurement are herewith as Appendix A[3].

Details of Glasgow base measurement were published as Appendix A[1b], Annual Report, Missouri River Commission, 1886.

	North latitude.	Longitude west from Greenwich.	
	° ′ ″	° ′ ″	
△ East Base, Glasgow ..	39 12 31.76	92 51 52.01	
△ Glasgow	39 14 11.490	92 58 52.050	Transferred from Morrison Observatory.
	39 14 12.577	92 58 40.978	Computed from △ Azimuth.
Difference	1.087	11.072	
△ Northeast Base, Beverly.	39 22 00.010	94 52 00.29	Transferred from Fort Leavenworth.
	39 21 58.930	94 52 11.36	Computed from △ east base, Glasgow.
Difference	1.080	11.07	
△ Azimuth	39 21 49.98	94 54 51.34	Transferred from Fort Leavenworth.
	39 21 48.89	94 55 02.41	Computed from △ east base, Glasgow.
Difference	1.08	11.07	

The latitude and longitude of △ Northeast Base, Beverly, were transferred from Fort Leavenworth as given in Annual Report, Chief of Engineers, U. S. Army, for 1881, p. 2838. This latitude was determined by zenith telescope in 1881 by Lieutenant Bailey; and the longitude was determined in 1872–'73 by telegraphic exchange of signals with Lake survey at Detroit, the Detroit observer being Mr. O. B. Wheeler himself, who has been in charge of this triangulation.

Latitude and longitude of △ East Base, Glasgow, were transferred from the Morrison Observatory, whose latitude has been twice determined with identical results and whose longitude was determined by five nights' exchange of telegraphicsignals with the Naval Observatory at Washington. These results are published in Publications of the Morrison Observatory, Glasgow, Mo., No. 1, 1885.

The transfers were made in each case by triangulation. Among the △ stations are twelve, established by the Coast Survey in their primary work. So the net from Fort Leavenworth to Saint Louis depends on two newly measured and determined bases, on 12 Coast Survey primary △ stations and the connecting 6 Coast Survey primary trianleg sides which serve as so many check bases.

The bases and discrepancies in lengths of lines as computed from the Glasgow base are as follows:

Bases.	Length.	Discrepancies.	
		In 7 place logs.	Ratio.
	Meters.		
Beverly (measured)	2418.11	Too small by 305	1 in 15,000
Glasgow (measured)	2414.94		
Cedar—Medlock (Coast Survey)	17252.77	Too large by 199	1 in 22,000
Berger—Enoch Knob (Coast Survey)	13696.33	Too small by 128	1 in 30,000
Enoch Knob—Dieckhaus (Coast Survey)	16732.46	Too small by 286	1 in 15,000
Dieckhaus—Halleck (Coast Survey)	13351.50	Too small by 197	1 in 22,000
Tavern Rock—Kessler (Coast Survey)	16061.91	Too large by 108	1 in 40,000
Minoma—Sugar Loaf (Coast Survey)	23612.52	Too large by 265	1 in 16,000

These bases were taken as absolute and adjustment made for intermediate lines.

Azimuths and discrepancies as computed from the line △ Glasgow—△ East Base, are as follows:

Lines.	Azimuth.	Discrepancies.
Observed.		
(1) △ Azimuth to △ Northeast Base (Beverly)	265° 39′ 52″.35	Too small by 8″.57
(2) △ Glasgow to △ East Base (Glasgow)	25 04 09 .74	
Coast Survey.		
(3) △ Cedar to △ Medlock	103 25 42 .00	Too small by 7″.54

Azimuth (1) used from Fort Leavenworth to Glasgow. Azimuth (2) used from Glasgow to Cedar City. Azimuth (3) used from Cedar City to Saint Louis, and agreed to the nearest second with that of all the other Coast Survey lines. No adjustments were made for discrepancies in azimuth, because the plotted results would be inappreciable.

Latitudes and longitudes, if computed from Fort Leavenworth instead of from Glasgow would be respectively 1″.086 larger and 11″.068 smaller than the tabulated values; and if computed from Coast Survey values for △ Cedar, would be respectively 6″.582 larger and 3″.772 smaller than tabulated. The Coast Survey values depend on the Clarke spheroid of 1866 and standard astronomical data of 1881.

The distance covered from Fort Leavenworth to Saint Louis is 435 miles of river, involving 306 triangles. 595 angles entered the adjustment and their corrections were as follows:

Between 0″ and 1″	373
Between 1″ and 2″	182
Between 2″ and 3″	31
Between 3″ and 4″	9
	595

The year's field-work covered 240 miles of river, and cost $11,662, or, per mile	$48.59
Office-work covered 435 miles of river, and cost $3,230, or, per mile	7.42
Total cost per mile, season 1886–'87, secondary triangulation	56.01

There is still a gap not triangulated from Fort Leavenworth to Trover's Point of 1,520 miles.

The permanent bench-mark party began setting stones October 13, and stopped December 2. They had previously been engaged in fitting up three quarter-boats and a steam-launch at Kansas City for their own use and that of the the triangulation parties. A description of these permanent bench-marks and the method followed in establishing them was given in appendix A, annual report of this Commission for 1885 and in annual report for 1886. Nineteen lines were established during the autumn of 1886; the first was No. 79, just below the C., R. I. and P. R. R. Bridge at Fort Leavenworth, and, the last was No. 61, at Berlin Landing.

Length of river embraced ...miles	108.6
Number of lines established	19
Average distance between lines along river ...miles	6.33
Average distance between lines along axis of valley ...miles	4.10
Cost per mile of river	$25.55
Cost per line	146.06

It takes just as much money and time and labor to fit out a party for a short season's work as for a long season, and if we had been able to put this party in the field early in the spring, not only would they have been able to accomplish more than three times the amount of work, but its cost would have been surely 33 per cent. and possibly 50 per cent. less.

This party used wye-levels. These had been put in perfect order, and excellent results were obtained, the details of which are given in the report of Assistant Engineer D. W. Wellman, hereto appended, Appendix A 1. All bench-marks set were connected with previous surveys, either by stadia line or triangulation.

SPECIAL SURVEYS.

To enable the Commission to submit estimates for "necessary work at Omaha, Atchison, Saint Joseph, Fort Leavenworth Reservation, Arrow Rock, Kansas City, Plattsmouth, Brownville, and Nebraska City," in accordance with act of Congress of August 5, 1886, surveys of these places have been made. The results are reported in my report to you of June 30, 1887, together with maps of the localities showing the latest and former shore lines. Said report is hereto appended, marked App. C.

MISCELLANEOUS.

One hundred copies were printed of a letter from your office to the Chief of Engineers, U. S. Army, dated April 1, 1886, indicating the views of the Commission as to necessary requirements for bridges over the Missouri River, and were distributed to bridge engineers and others to whom the information was likely to be of use.

PHYSICAL DATA.

The compilation of all data on record relating to the Missouri River has been practically completed during the year, except for indexing and filing.

Discharge observations are appended, marked Appendix A 5. This tabulation is accompanied by explanatory and descriptive notes. Each measured discharge has a number assigned to it for convenience of reference and use. These discharges are as follows:

Locality.	Year.	Number taken.	Locality.	Year.	Number taken.
Sioux City, Iowa	1878	4	Saint Joseph, Mo	1878	5
Do	1879	26	Atchison, Kans	1882	6
Omaha, Nebr	1878	19	Kansas City, Mo	1883	61
Do	1879	8	Kansas City, Mo. (Kaw River)	1883	19
Do	1880	5	Saint Charles, Mo	1878	1
Do	1882	27	Do	1879	170
Nebraska City, Nebr	1882	33			

Method of computation and other details were given in last annual report.

Sediment observations were taken at Saint Charles, Mo., in 1879. The results have been tabulated and are hereto appended as Appendix A 5, with explanatory and descriptive notes, illustrated by two plates. It appears from Plate I that not only does the mean amount of sediment have a variation to gauge height, but also an independent time variation.

A mean specific gravity for the sediment observed on was deduced to be 1.6.

Plate II gives a very interesting comparison of these sediment observations taken at Saint Charles, and a series of similar observations taken in the Mississippi River, at Columbus, Ky., during a portion of the same time. The agreement between the total sediment at Saint Charles and at Columbus is marked and leads to the following conclusions:

(1) The sediment carried by water, reaching Columbus from other sources, is very small as compared with that carried by the water from the Missouri River.

(2) Nearly the same amount of sediment that is carried by the Missouri River at Saint Charles is carried by its water when it reaches Columbus.

Hence seems to follow the inference:

(3) That it is the same sediment carried in permanent suspension from Saint Charles to Columbus.

The preceding seems to justify the assumption:

(4) That there is a mean sediment per cubic foot representing saturation of discharge at any time, an assumption under which the total sediment was computed.

The ratio of areas included in the sediment variations gives total sediment past Saint Charles as 86 per cent. of total sediment past Columbus during the coincident period.

Study of the diagrams suggests the probability of a three-day interval between Saint Charles and Columbus. Again, water passing Saint Charles is more or less identified by its mean sediment per cubic foot, and hence when the same total sediment passes Columbus after a three-day interval the discharge also should be largely identical.

The study of the physical data during the year has progressed far enough to show—

(1) That increments from tributaries affect gauge heights differently from similar increments in regular rises.

(2) That at some localities this abnormal effect is very marked.

Study is at present being directed to the question whether said difference of effect is universal, and as to how closely it may be measured.

Mr. James A. Seddon has been in charge of this work, which he has conducted with fidelity and intelligent interest.

GAUGES.

Nineteen gauges have been read twice daily throughout the year. Their records have been carefully watched by plotting and other means and are complete and reliable.

The gauges in the Kansas City and Saint Joseph divisions have been inspected monthly under the direction of the division engineers. Their condition has been found so satisfactory that, owing to scarcity of funds, no systematic verification of all the gauges has been made during the year. Where any gauge has been damaged or has shown change by its record, it has, however, been set right. After the breaking up of the ice next spring all the gauges will need inspection and repairs, and a sum sufficient for that purpose has been reserved.

The bridge gauge described in last annual report has proved satisfactory.

COMMERCE.

An attempt was made in my last annual report to give a thorough statement of the commerce of the Missouri River for the preceding year (1885–'86). That report contains a full list of all boats plying on the river. But, as there explained, it is very difficult to give any accurate figures of the kinds and amounts of river freight handled. All our gauge-keepers are required to submit weekly reports, on blanks furnished them, of the boats which pass their gauges, showing amounts and kinds of freight. But the information so obtained is only approximate at best, and serves mainly as a check on information gathered from other sources. The commerce of the river is, in the main, from Saint Louis to Kansas City, for the lower river, and from Bismarck, Dak., to Fort Benton, Mont., for the upper. Some light boats run down from Bismarck to Yankton and Fort Yates, and there are some small boats that ply in the vicinity of Sioux City, Omaha, and Nebraska City.

LOWER RIVER.

Steamers Wyoming and Dacotah—Regular packets, Saint Louis to Kansas City, carry freight and passengers; best boats on this route.

Steamer C. C. Carroll—Occasional trips to Kansas City; generally runs to lower ports; freight exclusively.

General Meade—Does not often run above Rocheport; freight only.

A. S. Willis—Carries railroad ties to Glasgow and DeWitt; loads between Glasgow and Portland.

Carrie—Runs principally from Boonville up Lamine River.

Frederick and *Aggie*—Run above and below Jefferson City; cargoes usually wood and grain.

New Haven—Runs from Saint Louis to Saint Charles, Augusta, and New Haven.

Black Diamond—Runs in vicinity of Jefferson City; carries wood, hay, and wheat.

Tons moved on Missouri River (lower) 1886–'87.

Steamer.	Wheat.	Railroad ties.	Meat.	Lumber.	Pork.	Lard.	General merchandise.	Hogs.	Wood.
Wyoming	917	1,050	10	4	85	50	5,300		
Dacotah	2,040				100		3,975	69	
General Meade							182	41	
A. S. Willis		7,102							
C. C. Carroll							200		
Black Diamond							985		
Aggie	898								1,291
Carrie				131					
Frederick	169								
Total	4,024	6,152	10	135	185	50	10,642	110	1,291

Railroad ties taken as 7 inches by 9 inches, by 8½ feet, and weighing 179 pounds. A sack of wheat taken at 135 pounds. Average weight of hogs taken at 275 pounds. Bale of hay taken at 300 pounds.

In reducing cord-wood to tons it was assumed to be dry and to be red or black oak; ¼ of the volume was taken as void, and the weight of one cubic foot was taken as 38½ pounds.

Amount of freight either carried past or handled at various Lower Missouri River ports for season 1886-'87.

	Wyoming.	Dacotah.	General Meade.	C. C. Carroll.	A. S. Willis.	Black Diamond.	Carrie.	Frederick.	Aggie.	New Haven.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Saint Louis	6,765	4,634	223	200							11,822
Portland	6,765	4,634	223	200							11,822
Barkersville	6,765	4,634	223	200	6,005	440		135	695		19,097
Jefferson City	6,765	4,234	223	200	6,005	985	131	169	2,089		20,801
Claysville	6,765	4,634	115	200	6,005	210	131	101	676		18,837
Marion	6,765	4,634	115	200	6,005	210	131	101	676		18,837
Sandy Hook	6,765	4,634	115	200	6,005	150	131		529		18,529
Rocheport	6,765	4,634	115	200	6,005		131		101		18,951
Boonville	4,866	6,184		200	6,005		131		101		18,455
Lamine River	4,866	6,184		200	6,005		136				18,735
Arrow Rock	4,866	6,184		200	7,347		136				18,733
Glasgow	4,866	6,184		200	7,446		136				18,632
De Witt	4,866	6,184		200	1,454						12,724
Miami	4,866	6,184		200							11,250
Kansas City	4,866	6,184		200							11,250

In the preceding table if the *Wyoming* or *Dakota*, passed Jefferson City with a certain load, it was assumed that it was brought from Saint Louis, and was entered in the Saint Louis column. This supposition is right in most cases, but probably makes the Saint Louis figure too small, because freight may have been put off at intermediate points. Again, a cargo that passed Glasgow was assumed to have gone to Kansas City and was entered in the Kansas City column. This assumption is not strictly accurate (for probably some of it was put off at way points) and tends to make the Kansas City figure too large. It is highly probable, however, that the Kansas City and Saint Louis errors about balance each other.

Two small boats, perhaps ferry-boats *Vice President* and *Capitola*, made trips between Nebraska City and East Nebraska City, and probably ran a short distance up and down the river. Their cargoes usually consisted of grain, wood, coal, live stock, and a few emigrants. The following is an estimate of the amounts moved:

	Tons.
Vice President	100
Capitola	123
Total	223

The *Minnie Herman* ran in the vicinity of Sioux City. No estimate of cargo obtained.

UPPER RIVER.

General merchandise taken from Bismarck	tons	3,235
Hay and grain taken from Bismarck	do	500
Lumber taken from Bismarck	car-load	1
Hides brought to Bismarck	do	1

Amount of freight either carried past or handled at various Upper Missouri River ports for season 1886-'87.

	Rosebud.	Batchelor.	Helena.	Benton.	Eclipse.	General Terry.	General Tompkins.	Judith.	Missouri.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Yankton						175	175		
Fort Yates						325	175		
Bismarck	200	490	550	910	545	555	175	255	55
Little Missouri River	200	490	550	910	545	230		255	
Little Muddy	200	490	550	650	545	230		255	
Poplar River	200		550	650	545	230		255	
Fort Benton	200		550	400	545	230		255	

Two diagrams are herewith submitted, showing graphically the circumstances of the Missouri River trade for the year 1886–'87. The river ports are plotted as abscissas at their proper distances apart in miles. At each port are two ordinates, one showing by scale the number of boats passing each port, both up and down, the other showing by scale the tons of freight handled at or passing each port, both up and down. Lines are drawn through the extremities of these ordinates, thus giving a boat curve and a freight curve. Inspection of the diagram shows—

(1) The greatest number of boats in the Missouri River trade have their port at Saint Louis.

(2) Jefferson City and Glasgow are important ports, each having a considerable local river trade, which is mainly on rivers tributary to the Missouri. These ports are collecting and distributing points for a large section of interior country.

(3) The amount of freight actually handled on the river is greatest at Jefferson City, then at Glasgow, and, lastly, at Saint Louis and Kansas City.

(4) Inspection of the diagrams and accompanying sketch of river and railroads appears to show that the railroads probably do most of the carrying for the sections tributary to Jefferson City and Glasgow. Doubtless there is some local business done by the through boats between Saint Louis and Kansas City (Dacotah and Wyoming), but their commerce curve near Jefferson City and Glasgow shows very little change from what it is at the terminal points.

Mr. R. F. Grady deserves credit for his work in compiling these data.

Respectfully submitted.

THEO. A. BINGHAM,
First Lieutenant of Engineers.

Lieut. Col. CHARLES R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

TABLE I.—*Tabulated results of secondary triangulation from Fort Leavenworth, Kansas, to Saint Louis, Missouri.*

[Distances and azimuths are in the order of stations, first to second, second to third, third to first, in each triangle.]

Stations.	Observed angles.			Adjusted angles.		Distance.	Azimuth.			Latitude.			Longitude.		
	°	′	″	′	″	*Meters.*	°	′	″	°	′	″	°	′	″
Northeast base	87	28	14.06		13.30	2,418.11	48	13	27.5	39	21	58.93	94	52	11.36
Southwest base	108	36	27.06		27.81	2,636.01	119	36	12.0	39	21	06.68	94	53	26.67
Azimuth	83	55	17.40		18.89	4,106.54	265	39	52.4	39	21	48.90	94	55	02.44
			58.52		0.00										
Northeast base	65	09	46.52		44.86	4,106.54	85	41	40.8						
Azimuth	62	56	43.50		42.62	4,736.20	202	43	09.7						
Weston	51	53	31.24		32.52	4,647.84	330	50	25.7	39	24	10.55	94	53	45.96
			1.26		0.00										
Northeast base	55	00	53.42		51.57	4,647.84	150	51	25.7						
Weston	69	55	29.22		29.18	4,645.19	40	45	54.9						
Sheridan	55	03	38.06		39.25	5,325.27	275	48	13.8	39	22	16.45	94	55	52.07
			0.72		0.00										
Weston	68	35	24.25		26.34	4,645.19	40	45	54.9						
Sheridan	71	53	50.65		50.77	6,797.21	292	38	25.8						
Hellman	39	30	42.16		42.89	6,939.62	152	11	54.4	39	20	51.52	94	51	30.68
			57.06		0.00										
Sheridan	70	21	30.89		30.02	6,797.21	292	38	25.8						
Hellman	62	54	39.87		39.80	8,791.86	49	46	31.6						
Reservoir	46	43	49.91		50.18	8,311.00	182	59	43.8	39	17	47.82	94	56	10.82
			59.67		0.00										
Hellman	66	27	29.87		27.88	8,791.86	49	46	31.6						
Reservoir	41	05	34.96		34.10	8,453.57	270	49	08.2						
Spinner	72	27	00.31	26	58.02	6,060.84	163	19	49.6	39	17	43.25	94	50	18.08
			5.14		0.00										
Reservoir	43	13	37.43		37.53	8,453.57	270	49	08.2						
Spinner	68	22	55.03		57.18	6,227.47	22	29	54.4						
Delaware	68	23	24.69		25.35	8,453.11	144	05	26.2	39	14	36.67	95	51	57.45
			57.15		0.01										
Spinner	53	06	31.07		33.96	6,227.47	22	29	54.4						
Delaware	90	52	44.65		46.41	8,471.30	293	21	38.0						
Waldron	36	00	39.44		39.68	10,590.74	149	25	42.6	39	12	47.62	94	46	33.29
			55.16		0.00										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjusted angles.		Distance.	Azimuth.			Latitude.			Longitude.		
	°	'	"	'	"	Meters.	°	'	"	°	'	"	°	'	"
Delaware	29	57	37.41		37.30	8,471.30	293	21	38.0						
Waldron	59	11	05.12		04.86	4,231.04	54	13	58.2						
Conner	90	51	17.20		17.84	7,276.15	143	21	09.9	39	11	27.40	94	48	56.34
			59.73		0.00										
Waldron	86	12	14.79		16.21	4,231.04	54	13	58.2						
Conner	61	03	00.67		03.10	7,805.11	295	15	30.8						
Tanks	32	44	39.05		40.69	6,844.87	148	03	17.8	39	09	39.30	94	44	02.33
			54.51		0.00										
Waldron	45	53	07.52		08.76	6,814.87	328	01	42.0						
Tanks	71	50	34.34		34.57	5,551.86	219	53	51.9						
Parkville	62	16	16.41		16.67	7,347.86	102	11	42.4	39	11	57.40	94	41	32.98
			58.27		0.00										
Tanks	61	08	33.05		33.24	5,551.86	219	53	51.9						
Parkville	67	41	29.28		28.06	6,242.15	332	13	57.6						
Quindaro	51	09	57.93		58.70	6,593.72	101	05	15.4	39	08	58.27	94	39	33.83
			0.26		0.00										
Tanks	43	47	49.95		50.05	6,593.72	281	02	25.2						
Quindaro	74	37	01.41		03.41	5,188.66	175	42	18.8						
Carpenter	61	35	04.27		06.54	7,228.34	57	17	15.1	39	11	46.05	94	39	40.01
			55.63		0.00										
Quindaro	77	33	29.26		29.83	5,188.66	175	42	18.8						
Carpenter	58	18	50.01		50.30	7,272.69	287	23	18.3						
Todd	44	07	39.17		39.87	6,341.35	73	18	28.4	39	09	57.41	94	35	19.86
			58.44		0.00										
Quindaro	38	58	25.57		25.88	6,341.35	253	15	48.7						
Todd	102	52	15.54		15.87	6,456.04	330	26	12.5						
Kansas City	38	09	18.48		18.25	10,006.63	112	18	18.0	39	06	55.29	94	33	07.28
			59.59		0.00										
Todd	66	19	59.91	20	01.87	6,456.04	330	26	12.5						
Kansas City	67	12	07.97		08.54	8,156.65	217	39	44.8						
Buster	46	27	48.61		49.59	8,209.90	84	09	45.4	39	10	24.63	94	29	29.66
			56.49		0.00										
Kansas City	35	04	56.86		58.52	8,156.65	217	39	44.8						
Buster	108	05	46.64		48.96	7,821.59	289	36	06.9						
Wayne	36	49	08.58		12.52	12,936.91	72	50	08.2	39	08	59.41	94	24	38.77
			52.08		0.00										
Buster	35	51	03.91		02.78	7,822.59	289	36	06.9						
Wayne	108	41	22.72		22.15	7,897.36	218	20	42.9						
Saint Bernard	35	27	35.53		35.08	12,773.15	78	50	26.9	39	12	20.21	94	21	08.86
			2.16		0.01										
Wayne	30	13	32.38		33.73	7,897.36	218	20	42.9						
Saint Bernard	40	42	41.66		42.60	4,206.27	357	40	09.3						
Blue Mills	109	03	41.89		43.66	5,449.94	68	36	30.1	39	10	03.93	94	21	01.44
			55.43		59.99										
Saint Bernard	84	06	56.59		57.85	4,206.27	357	40	09.3						
Blue Mills	67	38	08.25		09.48	8,840.50	245	18	23.2						
Little Blue	28	14	52.16		52.67	8,218.87	93	36	47.5	39	12	03.56	94	15	26.70
			57.00		0.00										
Saint Bernard	40	33	10.92		12.32	8,218.87	273	33	11.4						
Little Blue	49	50	17.20		16.64	5,343.67	143	27	04.1						
Missouri City	89	36	30.94		31.04	6,281.20	58	02	11.3	39	14	22.74	94	17	39.39
			59.06		0.00										
Little Blue	60	04	37.78		37.22	5,343.67	143	27	04.1						
Missouri City	73	50	18.91		19.13	6,429.18	249	35	21.1						
Cooley	46	05	03.83		03.65	7,124.88	23	32	56.4	39	15	35.37	94	13	28.07
			0.52		0.00										
Little Blue	48	32	18.63		16.87	7,124.88	203	31	41.4						
Cooley	92	42	44.96		43.50	8,530.38	290	50	12.9						
Orrick	38	45	03.61	44	59.63	11,370.25	72	08	43.6	39	18	56.84	94	07	55.67
			7.22		0.00										
Little Blue	54	36	41.37		41.84	11,370.25	252	08	58.2						
Orrick	40	43	07.90		09.39	9,309.80	31	25	34.1						
Hudson	84	40	06.88		08.77	7,449.64	126	43	17.6	39	09	39.19	94	11	17.85
			56.10		0.00										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjusted angles.		Distance	Azimuth.			Latitude.			Longitude.		
	°	′	″	′	″	*Meters.*	°	′	″	°	′	″	°	′	″
Orrick	89	43	41.13		42.48	9,809.80	21	25	34.1						
Hudson	37	44	15.66		16.37	11,729.82	249	07	42.7						
Ralph	52	32	00.65		01.15	7,179.01	121	44	32.4	39	11	54.45	94	03	41.12
			57.44		0.00										
Hudson	30	08	31.70		32.15	11,729.82	249	07	42.7						
Ralph	102	16	46.88		47.28	7,978.72	326	55	43.9						
Wellington	47	34	39.78		40.57	15,525.64	99	22	57.9	39	08	17.59	94	00	39.84
			58.36		0.00										
Ralph	40	55	42.84		40.37	7,978.72	326	55	43.9						
Wellington	106	38	22.38		20.73	9,746.01	253	35	59.2						
Odell	32	25	58.63		58.90	14,254.02	106	06	04.2	39	09	46.65	93	54	10.41
			3.85		0.00										
Wellington	77	03	38.56		37.96	7,475.90	176	32	21.2						
Camden	60	52	06.50		08.30	10,873.98	295	40	01.1	39	12	19.58	94	00	58.65
Odell	42	04	14.80		13.74	9,746.01	73	40	03.3						
			59.86		0.00										
Odell	38	40	37.83		37.46	10,873.98	115	44	19.0						
Camden	66	49	22.62		20.66	7,051.94	228	50	40.4						
Junction	74	30	01.86		01.88	10,373.59	334	22	58.4	39	14	50.01	93	57	17.22
			2.31		0.00										
Camden	49	59	04.68		05.34	7,051.94	228	50	40.4						
Junction	97	27	15.70		16.72	9,236.17	311	25	43.6						
Lexington	34	33	38.11		37.93	12,326.37	96	55	08.1	39	11	31.74	93	52	28.65
			58.49		59.99										
Odell	95	34	45.07		44.25	10,373.59	154	24	56.5						
Junction	46	25	21.16		23.17	16,770.44	287	57	35.2						
Sheep's Nose	37	59	50.75		52.58	12,207.14	70	04	43.0	39	12	01.80	93	46	12.37
			56.98		0.00										
Odell	85	28	03.44		01.39	12,207.14	249	59	40.7						
Sheep's Nose	42	46	41.17		42.77	15,494.50	112	51	25.8						
Help	51	45	17.28		15.84	10,556.38	344	30	25.1	39	15	16.54	93	56	07.86
			01.89		0.00										
Sheep's Nose	75	11	50.77		51.97	15,494.50	112	51	25.8						
Help	46	21	34.89		34.69	17,580.11	246	23	34.6						
Carroll	58	26	32.77		33.34	13,159.17	8	04	06.6	39	19	04.30	93	44	55.40
			58.43		0.00										
Sheep's Nose	62	35	23.24		22.37	13,159.17	188	03	17.8						
Carroll	43	39	40.61		38.43	12,167.92	324	24	28.1						
Dover	73	44	59.34		59.20	9,462.96	70	42	35.8	39	18	43.34	93	40	00.14
			3.19		0.00										
Sheep's Nose	43	30	32.34		31.44	15,235.96	207	03	08.8						
Narborne	37	53	10.98		12.27	10,608.82	349	18	00.1	39	19	21.38	93	41	22.26
Dover	98	36	17.08		16.29	9,462.96	70	42	35.8						
			0.30		0.00										
Narborne	90	34	11.17		11.85	10,608.82	349	18	00.1						
Dover	55	12	00.29		59.61	18,858.55	224	30	51.7						
Carrollton	31	13	48.00		48.54	15,486.43	78	50	29.9	39	20	59.04	93	30	47.97
			59.46		0.00										
Narborne	67	20	53.45		52.60	12,876.74	326	04	40.8						
Doris	64	11	19.45		19.53	15,875.65	210	19	10.1	39	13	34.78	93	36	22.68
Carrollton	48	27	50.53		47.87	15,486.43	78	50	29.9						
			3.43		0.00										
Doris	63	31	24.16		24.60	15,875.65	210	19	10.1						
Carrollton	44	47	06.70		07.48	14,968.30	345	35	31.5						
Gilham	71	41	28.38		27.92	11,779.99	93	55	44.9	39	13	08.90	93	28	12.72
			59.24		0.00										
Carrollton	61	42	07.71		09.44	11,320.28	283	53	25.1						
Wakenda	72	13	35.99		38.01	13,840.07	31	44	37.5	39	19	30.66	93	23	09.19
Gilham	46	04	12.41		12.55	14,968.30	165	37	12.8						
			56.11		0.00										
Gilham	53	10	06.88		06.30	13,840.07	211	41	25.4						
Wakenda	58	15	20.71		22.34	11,899.89	333	29	15.1						
Malta	68	34	32.49		31.36	12,643.38	84	57	04.0	39	13	45.32	93	19	27.72
			00.08		0.00										

TALBE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
	° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
Wakenda	71 24 35.13	36.43	11,809.80	333 29 15.1		
Malta	42 30 08.04	08.80	12,338.04	196 01 44.2		
White Rock	66 05 14.35	14.77	8,794.71	82 08 29.0	39 20 09.82	93 17 05.47
	57.52	0.00				
Wakenda	24 35 19.06	19.58	8,794.71	263 04 38.7		
White Rock	109 36 15.81	16.24	5,103.96	332 32 12.9		
Marshall	45 48 24.24	24.18	11,555.06	106 44 50.9	39 17 42.95	93 15 27.24
	59.11	0.00				
White Rock	107 44 31.15	31.83	5,103.96	332 32 12.9		
Marshall	40 47 37.39	38.32	9,318.34	193 20 53.3		
De Witt	31 27 47.77	49.85	6,388.65	41 49 40.1	39 22 36.78	93 13 57.41
	56.31	0.00				
White Rock	79 37 21.70	20.87	6,388.65	224 47 40.9		
De Witt	55 40 07.74	08.87	8,132.68	349 09 31.2		
Longview	44 42 31.12	30.26	7,499.25	124 27 45.4	39 17 52.29	93 12 47.29
	0.56	0.00				
De Witt	54 30 04.54	05.54	8,932.68	349 09 31.2		
Longview	42 28 55.98	56.82	7,326.74	211 39 12.5		
Hawkins	83 00 57.41	57.64	6,077.90	114 41 52.0	39 21 14.50	93 10 06.70
	57.88	0.00				
De Witt	55 59 38.32	39.41	6,077.90	294 39 25.7		
Hawkins	87 40 29.14	28.82	8,504.45	202 22 20.8		
Brunswick	36 19 49.68	51.77	10,250.48	58 43 38.5	39 25 29.48	93 07 51.37
	57.14	0.00				
Hawkins	97 34 58.05	58.95	8,504.45	202 22 20.8		
Brunswick	47 21 15.87	15.88	14,674.50	335 02 30.8		
High Hill	35 03 44.64	45.17	10,889.18	120 01 29.5	39 18 18.00	93 03 32.94
	58.06	0.00				
Brunswick	50 46 09.26	09.70	14,674.50	335 02 30.8		
High Hill	55 09 39.45	39.08	11,820.91	210 14 58.8		
Dalton	74 04 11.28	11.22	12,525.24	104 21 42.8	39 23 49.05	92 59 24.06
	59.99	0.00				
High Hill	30 02 47.83	48.41	11,820.91	210 14 58.8		
Dalton	76 03 19.07	22.23	6,160.51	314 14 09.3		
Bluff Rock	73 53 48.72	49.36	11,941.07	60 22 16.8	39 21 29.65	92 56 19.73
	55.12	0.00				
High Hill	53 41 15.46	16.67	11,941.07	240 17 42.2		
Bluff Rock	30 23 43.41	41.47	9,673.69	29 58 35.4		
Frankfurt	95 55 01.11	01.86	6,074.02	114 01 25.7	39 16 57.88	92 59 41.30
	59.98	0.00				
Bluff Rock	72 54 49.64	51.05	9,673.69	29 58 35.4		
Frankfurt	42 59 26.40	26.96	10,279.64	252 55 54.5		
Bender	64 05 41.58	41.99	7,333.13	137 05 56.3	39 18 35.51	92 52 51.22
	57.62	0.00				
Bluff Rock	51 03 45.20	45.36	7,333.13	317 03 44.3		
Bender	90 00 09.21	08.79	9,076.39	47 05 47.5		
Cambridge	38 56 06.04	05.85	11,668.83	188 06 46.1	39 15 15.06	93 57 23.59
	0.45	0.00				
Bender	66 26 26.81	26 14	9,076.39	47 05 47.5		
Cambridge	54 34 06.09	06.08	9,707.10	281 36 58.0		
Glasgow	58 59 26.57	27.78	8,628.65	160 40 36.6	39 14 11.49	92 50 52.05
	59.47	0.00		[Changed to Glas. Az.]		
Glasgow	78 13 59.87	59.67	9,707.10	101 41 00.3		
Cambridge	38 23 48.88	48.90	10,630.86	320 00 46.9		
Bluffport	63 22 10.55	11.44	6,744.60	203 25 49.9	39 10 50.83	92 52 43.87
	59.30	0.01				
Glasgow	36 12 05.67	05.55	6,744.60	23 27 00.6		
Bluffport	37 08 32.75	33.66	4,158.00	166 17 16.3		
West Base	106 39 21.10	20.79	4,250.75	239 37 29.5	39 13 01.82	92 53 24.96
	59.58	0.00				
Glasgow	34 31 55.50	56.42	3,395.26	25 04 09.74	39 12 31.76	92 51 52.01
East Base	92 28 39.19	42.07	2,414.94	112 34 49.75		
West Base	52 56 20.80	21.51	4,250.75	239 37 29.46		
	55.49	0.00				

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjusted angles.	Distance.	Azimuth.			Latitude.			Longitude.		
	°	′	″	′ ″	*Meters.*	°	′	″	°	′	″	°	′	″
Glasgow	34	46	11.15	10.49	6,744.60	23	27	00.6						
Bluffport	92	54	08.48	07.88	4,859.33	110	31	42.0						
Duncan	52	19	41.64	41.68	8,510.08	238	10	00.5	39	11	46.05	92	55	58.51
			1.27	0.00										
Bluffport	91	26	48.99	46.25	4,859.33	110	31	42.0						
Duncan	46	11	47.59	49.27	7,210.12	336	41	31.4						
Crowley	42	21	26.26	24.48	5,205.37	199	04	10.9	39	08	11.30	92	53	54.73
			57.84	0.00										
Bluffport	52	45	36.21	39.20	5,205.37	19	04	55.8						
Crowley	64	44	31.24	31.80	4,672.09	134	19	39.2						
Aid	62	29	50.00	49.00	5,307.55	251	48	22.2	39	00	57.15	92	56	13.94
			0.45	0.00										
Crowley	37	38	05.72	03.99	5,307.55	134	19	39.2						
Aid	53	57	51.92	51.87	2,853.99	8	16	08.1						
Saline	88	24	06.10	04.14	3,779.56	276	39	56.5	39	08	25.56	92	56	31.03
			3.74	0.00										
Crowley	100	59	17.98	21.13	3,779.56	96	41	35.2						
Saline	45	55	32.04	34.19	6,796.86	322	35	30.7						
Lisbon	33	05	03.20	04.68	4,974.38	175	42	23.8	39	05	30.45	92	53	39.22
			53.22	0.00										
Saline	39	29	45.66	46.57	6,796.86	322	35	30.7						
Lisbon	91	07	51.70	51.02	5,695.91	51	29	28.1						
Arrow Rock	49	22	22.55	22.41	8,953.71	182	05	08.8	39	03	35.40	92	56	44.60
			59.91	0.00										
Lisbon	81	42	24.27	22.59	5,695.91	182	05	08.8						
Arrow Rock	58	48	13.66	11.98	8,862.86	290	15	43.2						
Hayter	39	29	27.11	25.43	7,661.34	149	48	46.5	39	01	55.73	92	59	58.92
			5.04	0.00										
Arrow Rock	31	47	36.45	36.22	8,862.86	290	15	43.2						
Hayter	91	03	13.18	12.94	5,558.06	19	16	08.1						
Lamine	57	09	11.08	10.84	10,547.70	142	06	09.1	38	59	05.58	92	52	15.13
			0.71	0.00										
Hayter	84	32	11.93	11.79	5,558.06	19	16	08.1						
Lamine	48	50	45.31	45.20	7,612.72	248	06	05.2						
Chapel	46	37	00.94	03.01	5,758.09	114	46	13.0	39	00	37.55	92	47	21.55
			58.18	0.00										
Chapel	99	07	49.59	49.40	7,612.72	68	09	09.9						
Lamine	29	39	49.70	49.54	9,643.62	277	45	54.7						
Boonville	51	12	21.76	21.07	4,833.96	149	02	25.6	38	58	23.14	92	45	38.20
			1.05	0.01										
Chapel	56	19	14.19	11.89	4,833.96	329	01	20.5						
Boonville	101	01	14.30	13.64	10,441.29	250	03	39.2						
Farris	22	39	36.29	34.47	12,316.01	92	47	30.4	39	00	18.41	92	38	50.27
			4.78	0.00										
Boonville	31	59	06.82	08.65	10,441.29	250	03	39.2						
Farris	44	38	19.34	20.31	5,685.03	25	29	35.6						
Combs	103	22	28.02	31.04	7,540.98	102	06	00.6	38	57	31.98	92	40	31.90
			54.18	0.00										
Farris	66	22	08.99	10.10	5,685.03	25	29	35.6						
Combs	70	53	52.92	54.34	7,675.43	276	22	26.0						
Hays	42	43	56.99	55.56	7,916.64	139	09	40.8	38	57	04.23	92	35	15.12
			58.90	0.00										
Farris	24	59	12.27	13.43	7,916.64	319	07	25.5						
Hays	100	23	26.39	26.37	4,101.40	239	33	07.2						
Rocheport	54	37	18.36	20.20	9,550.23	114	11	59.7	38	58	11.61	92	32	48.25
			57.02	0.00										
Hays	66	12	41.04	43.78	4,101.40	239	33	07.2						
Rocheport	38	38	19.54	19.79	3,882.66	20	56	19.7						
Aux	75	08	56.98	56.43	2,649.45	125	46	47.0	38	56	14.01	92	33	45.86
			0.56	0.00										
Rocheport	62	41	27.16	25.04	3,882.66	20	56	19.7						
Aux	74	12	39.06	36.84	5,049.12	275	08	20.3						
Searcy	43	05	59.77	58.12	5,467.96	138	16	29.6	38	55	59.29	92	30	17.08
			5.99	0.00										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjust'd angles.	Distance.	Azimuth.			Latitude.			Longitude.		
	°	′	″	′ ″	*Meters.*	°	′	″	°	′	″	°	′	″
Aux	38	05	52.19	52.40	5,049.12	275	08	20.3						
Searcy	44	36	13.10	13.62	3,140.78	50	34	17.9						
Hopkins	97	17	53.50	53.98	3,574.46	183	15	20.7	38	54	54.59	92	31	51.77
			58.79	0.00										
Searcy	68	33	31.71	31.33	3,140.78	50	34	17.9						
Hopkins	88	02	03.48	01.77	7,358.80	318	35	16.4						
Mount Vernon	23	24	28.43	26.90	7,901.30	162	01	50.1	38	51	55.57	92	28	35.87
			3.62	0.00										
Searcy	27	19	32.90	32.96	7,901.30	342	00	46.6						
Mount Vernon	114	54	20.94	20.08	5,922.02	276	56	10.2						
Warren	37	46	07.69	07.01	11,700.90	184	44	50.2	38	51	32.31	92	34	32.64
			1.53	0.00										
Mount Vernon	47	00	38.09	39.06	5,922.02	276	56	10.2						
Warren	82	17	30.00	30.81	5,593.08	14	41	12.3						
Denton	50	41	49.96	50.13	7,583.90	143	58	45.3	38	48	36.69	92	25	30.88
			58.05	0.00										
Warren	34	22	58.35	58.40	5,598.08	14	41	12.3						
Denton	29	39	16.96	15.63	3,516.21	224	19	51.1						
Providence	115	57	47.83	45.97	3,080.64	160	18	40.9	38	49	58.25	92	23	49.01
			2.64	0.00										
Denton	94	45	45.81	47.82	3,516.21	224	19	51.1						
Rrovidence	58	15	51.10	53.99	7,725.76	346	05	01.9						
Wright	26	58	19.61	19.19	6.593.43	139	07	30.9	38	45	55.05	92	22	32.06
			56.52	0.00										
Denton	26	43	36.88	36.84	6,593.43	319	05	38.9						
Wright	42	18	11.83	09.38	3,175.66	96	49	21.5						
Fisher	110	58	15.45	13.78	4,752.47	165	49	46.0	38	46	07.26	92	24	42.66
			3.66	0.00										
Wright	88	26	08.65	10.19	3,175.66	96	49	21.5						
Fisher	63	28	05.73	06.75	6,740.72	340	16	05.5						
Marion	28	05	43.65	43.06	6,033.09	188	22	48.6	38	42	41.49	92	23	06.47
			58.03	0.00										
Wright	41	56	20.50	21.42	6,033.09	8	23	11.4						
Marion	77	52	54.86	53.74	4,647.58	266	15	42.3						
Griffen	60	10	44.96	44.84	6,798.94	146	28	37.2	38	42	51.27	92	19	56.51
			0.32	0.00										
Marion	67	04	45.85	47.56	4,647.58	266	15	42.3						
Griffen	83	12	56.27	57.49	8,638.66	3	04	44.9						
Medlock	29	42	14.31	14.95	9,313.48	153	22	17.9	38	38	11.52	92	20	15.70
			55.93	0.00										
Griffen	58	06	36.81	35.91	8,638.66	3	04	44.9						
Medlock	69	51	20.47	20.18	9,303.57	252	55	53.2						
Quinn	52	02	03.48	03.91	10,287.18	125	01	46.8	38	39	39.92	92	14	07.85
			0.76	0.00										
Medlock	30	22	29.28	28.28	9,393.57	252	55	53.2						
				[C. and G. S. Azimuth hereafter.]										
Quinn	122	36	33.08	32.52	10,356.36	*310	23	10.4						
Cedar	27	00	56.95	59.20	17,252.77	103	25	42.0	38	36	02.15	92	08	41.86
			59.31	0.00										
Quinn	35	02	00.54	159.03	12,340.79	345	25	17.0						
Ulrich	56	59	58.84	58.95	7,088.74	222	26	35.9	38	33	12.55	92	11	59.56
Cedar	87	58	00.50	02.02	10,356.36	130	26	41.2						
			59.88	0.00										
Ulrich	46	55	11.91	12.17	7,088.74	222	26	35.9						
Cedar	89	27	58.26	57.84	7,506.05	313	00	41.2						
Ewing	43	36	49.41	49.99	10,276.17	89	26	12.5	38	33	16.04	92	04	55.19
			59.58	0.00										
Cedar	52	09	58.73	58.00	7,506.05	313	00	41.2						
Ewing	66	48	31.63	32.63	6,776.45	199	51	35.2						
Agent	61	01	28.85	29.37	7,886.78	80	54	03.9	38	36	42.72	92	03	20.04
			58.21	0.00										
Ewing	72	25	25.24	24.09	6,776.45	199	51	35.2						
Agent	51	22	36.40	36.72	7,774.05	328	29	57.8						
Osage	56	12	00.04	1159.19	6,371.06	92	19	43.3	38	33	07.72	92	00	32.29
			1.68	0.00										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjusted angles.	Distance.	Azimuth.			Latitude.			Longitude.		
	°	′	″	′ ″	Meters.	°	′	″	°	′	″	°	′	″
Agent	74	19	44.51	43.26	7,774.05	328	29	57.8						
Osage	44	04	26.76	26.54	8,509.39	192	36	09.0						
Pres	61	35	52.10	50.20	6,147.54	74	13	47.1	38	37	37.03	91	59	15.53
			3.37	0.00										
Osage	38	47	17.99	17.46	8,509.39	192	36	09.0						
Pres	73	45	11.06	10.32	5,771.58	298	51	46.6						
Isbell	67	27	33.54	32.22	8,845.30	51	26	24.7	38	36	06.63	91	55	46.65
			2.59	0.00										
Pres	55	09	31.13	29.92	5,771.58	298	51	46.6						
Isbell	79	06	46.05	44.62	6,615.38	198	00	41.6						
Bagby	45	43	44.71	45.46	7,915.24	63	45	19.8	38	39	30.65	91	54	22.05
			1.89	0.00										
Isbell	31	38	10 40	09.63	6,615.38	198	00	41.6						
Bagby	87	09	18.35	19.29	3,959.38	290	52	15.1						
Saint Aubert	61	12	31.19	31.08	7,539.24	49	41	19.6	38	38	44.87	91	51	49.06
			59.94	0.00										
Bagby	57	25	45.70	45.79	3,959.38	290	52	15.1						
Saint Aubert	88	25	29.88	28.46	5,944.54	199	19	19.1						
Harrison	34	08	44.06	45.75	7,051.25	53	28	55.7	38	41	46.79	91	50	27.67
			59.64	0.00										
Saint Aubert	46	18	39.71	38.27	5,944.54	199	19	19.1						
Harrison	69	57	55.82	56.61	4,793.83	309	22	13.4						
Chamois	63	43	25.64	25.12	6,228.41	65	40	24.0	38	40	08.15	91	47	54.38
			0.67	0.00										
Harrison	48	36	55.42	55.98	4,793.83	309	22	13.4						
Chamois	99	46	12.76	13.27	6,861.53	229	10	02.5						
Portland	31	36	50.29	50.80	9,012.50	80	49	07.6	38	42	33.59	91	44	19.51
			58.47	0.00										
Chamois	38	22	47.44	46.72	6,861.53	229	10	02.5						
Portland	68	21	24.30	23.58	4,448.58	340	50	53.2						
Townley	73	15	50.43	49.70	6,659.90	87	35	41.2	38	40	17.30	91	43	19.14
			2.17	0.00										
Portland	71	17	35.18	36.14	4,448.58	340	50	53.2						
Townley	76	45	08.68	08.98	7,961.57	237	36	39.9						
Bluffton	31	57	14.74	14.88	8,181.98	89	36	48.7	38	42	35.51	91	38	40.88
			58.60	0.00										
Townley	40	37	27.08	26.25	7,961.57	237	36	39.9						
Bluffton	73	13	02.70	02.53	5,667.33	344	26	31.3						
Morrison	66	09	31.59	31.22	8,333.58	96	17	39.4	38	39	38.45	91	37	38.01
			1.37	0.00										
Bluffton	71	15	22.87	24.64	5,667.33	344	26	31.3						
Morrison	45	52	21.94	23.15	6,090.28	210	19	33.8						
Miller	62	52	10.64	12.21	4,570.94	93	13	04.7	38	42	27.24	91	35	32.00
			55.45	0.00										
Morrison	47	01	59.94	2 00.08	6,090.28	210	19	33.8						
Miller	87	46	26.52	25.83	6,219.57	302	34	26.7						
Fey	45	11	33.63	34.09	8,498.14	77	25	06.2	38	40	38.58	91	31	55.17
			0.09	0.00										
Miller	57	30	22.21	21.81	6,219.57	302	34	26.7						
Fey	75	22	22.11	21.97	7,158.76	197	59	04.2						
Boland	47	07	16.50	16.22	8,212.41	65	07	17.7	38	44	19.39	91	30	23.65
			0.82	0.00										
Fey	60	22	21.46	21.60	7,158.76	197	59	04.2						
Boland	79	06	04.90	05.01	9,576.66	298	53	56.4						
Hermann	40	31	33.05	33.39	10,818.30	78	26	00.1	38	41	40.16	91	24	36.71
			59.31	0.00										
Boland	36	37	49.16	49.35	9,576.66	298	53	56.4						
Hermann	69	17	15.61	15.80	5,941.79	188	14	49.2						
Red	74	04	54.65	54.85	9,314.91	82	20	06.3	38	44	59.86	91	24	01.42
			59.42	0.00										
Hermann	103	57	25.20	25.01	5,941.79	188	14	49.2						
Red	44	38	26.70	26.86	11,066.99	323	36	44.5						
Kellner	31	24	07.85	08.13	8,012.90	112	15	26.2	38	40	10.84	91	19	29.84
			59.75	0.00										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjusted angles.	Distance.	Azimuth.			Latitude.			Longitude.		
	°	′	″	′ ″	*Meters.*	°	′	″	°	′	″	°	′	″
Hermann	83	11	09.85	09.72	5,941.79	188	14	49.2						
Red	64	40	57.39	55.76	11,092.65	308	34	15.6						
Lost	32	07	55.18	54.52	10,098.52	91	30	20.2	38	41	40.76	91	17	38.[illegible]
			2.42	0.00										
Hermann	45	03	26.49	26.10	10,098.52	271	25	59.0						
Lost	92	39	16.29	15.73	10,623.09	358	51	04.5						
Berger	42	17	19.54	18.17	14,992.20	136	33	51.5	38	35	56.32	91	17	30.1[illegible]
			2.32	0.00										
Lost	66	58	12.04	14.48	10,623.09	358	51	04.5						
Berger	37	21	24.01	24.59	10,090.34	216	12	34.4						
School	75	40	18.43	20.93	6,652.77	111	55	29.5	38	40	20.28	91	13	23.[illegible]
			54.48	0.00										
Lost	48	36	09.57	10.67	6,652.77	291	52	49.9						
School	69	48	59.85	49 02.54	5,674.43	42	06	26.9						
Etlah	61	34	46.50	46.79	7,099.97	160	30	01.7	38	38	03.72	91	16	00.9[illegible]
			55.92	0.00										
Berger	63	22	44.15	45.60	10,090.34	216	12	34.4						
School	72	06	20.58	22.52	12,866.74	324	08	45.9						
Enoch Knob	44	30	51.21	51.88	13,696.33	99	41	08.4	38	34	41.96	91	08	12.2[illegible]
			55.94	0.00										
Berger	47	35	57.53	59.44	10,090.34	216	12	34.4						
School	55	57	54.40	55.69	7,665.09	340	17	12.7						
Maupin	76	26	04.82	04.87	8,601.88	83	52	14.5	38	36	26.25	91	11	36.7[illegible]
			56.75	0.00										
School	42	06	40.91	40.68	7,665.09	340	17	12.7						
Maupin	78	09	35.62	36.20	5,951.50	238	27	55.5						
Emily	59	43	44.93	43.12	8,686.43	118	13	49.6	38	38	07.15	91	08	07.0[illegible]
			1.46	0.00										
Maupin	64	32	03.18	03.64	5,951.50	238	27	55.5						
Emily	57	21	10.60	10.43	6,328.29	1	08	56.1						
Enoch Knob	58	06	46.30	45.93	5,901.89	123	02	06.9	38	34	41.96	91	08	12.2[illegible]
			0.08	0.00										
Emily	38	42	52.83	51.11	6,328.29	1	08	56.1						
Enoch Knob	50	53	20.38	18.53	3,958.03	232	02	11.4						
Dundee	90	23	53.93	50.36	4,910.36	142	27	22.2	38	36	00.90	91	06	08.29
			7.14	0.00										
Enoch Knob	55	02	32.91	32.06	3,958.03	232	02	11.4						
Dundee	99	39	41.93	45.39	7,592.08	312	23	46.4						
Noelker	25	17	Comp't	42.55	9,132.05	107	08	28.2	38	33	14.82	91	02	11.74
				0.00										
Dundee	66	01	19.27	19.27	7,592.08	312	23	46.4						
Noelker	44	10	Comp't	54.28	7,391.66	176	37	05.1						
Tuque	69	47	46.45	46.45	5,638.07	66	24	40.4	38	37	14.12	90	02	29.77
				0.00										
Noelker	68	28	41.22	43.37	7,391.66	176	37	05.1						
Tuque	63	00	35.53	35.53	9,179.54	293	36	18.4						
Dieckhouse	48	30	Comp't	41.10	8,792.77	65	09	14.2	38	35	14.77	90	56	42.2[illegible]
				0.00										
Noelker	69	03	13.30	13.61	8,792.77	245	05	48.5						
Dieckhouse	72	59	30,46	30.54	13,351.50	352	09	42.5						
Halleck	87	57	15.93	15.86	13,671.04	134	13	14.4	38	28	05.80	90	53	27.11
			59.69	0.01										
Dieckhouse	76	07	42.44	42.94	13,351.50	352	09	43.5						
Halleck	39	06	22.40	24.06	14,329,53	211	16	54.2						
Engel	64	45	49.86	53.00	9,310.10	96	05	58.6	38	34	42.86	90	50	19.7[illegible]
			54.70	0.00										
Dieckhouse	62	18	28.78	28.88	9,310.10	276	02	00.6						
Engel	43	53	48.50	49.84	8,584.63	52	12	08.8						
Ming	73	47	41.15	41.27	6,722.40	158	21	33.1	38	31	52.13	90	54	59.7[illegible]
			58.43	59.99										
Engel	91	14	59.46	59.08	8,584.63	52	12	08.8						
Ming	26	52	30.21	29.76	9,731.66	259	01	44.2						
Meyer	61	52	32.70	31.17	4,400.19	140	58	21.1	38	32	52.02	90	48	25.[illegible]
			2.37	0.01										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

Stations.	Observed angles.			Adjusted angles.		Distance.	Azimuth.			Latitude.			Longitude.		
	°	′	″	′	″	*Meters.*	°	′	″	°	′	″	°	′	″
gel	99	15	00.11		00.44	4,400.19	320	57	09.7						
yer	38	39	32.05		32.56	6,479.00	179	37	53.7						
ed	42	05	26.70		27.00	4,100.47	41	43	19.7	38	36	22.13	90	48	26.98
			58.86		0.00										
yer	36	52	40.47		41.10	6,479.00	179	37	53.7						
ed	87	49	31.35		31.26	4,729.42	271	48	21.4						
vern Rock	55	17	47.67		47.64	7,875.27	36	32	35.7	38	36	17.25	90	45	11.62
			59.49		0.00										
ed	65	45	27.04		26.40	4,729.42	271	48	21.4						
vern Rock	48	54	24.30		24.12	4,745.22	140	44	47.4						
rsons	65	20	09.31		09.48	3,922.09	26	03	39.4	38	38	16.40	90	47	15.76
			0.65		0.00										
vern Rock	89	26	09.86		11.63	4,745.22	140	44	47.4						
rsons	55	23	59.75	24	00.55	8,239.05	265	19	29.4						
ild Horse	35	09	47.91		47.82	6,782.20	50	13	13.6	38	38	38.04	90	41	36.21
			57.52		0.00										
rsons	28	36	16.85		15.27	8,239.05	265	19	29.4						
ild Horse	74	53	50.41		49.77	4,056.61	160	16	51.2						
mburg	76	29	56.21		54.96	8,180.54	56	46	10.8	38	40	41.88	90	42	32.83
			3.47		0.00										
vern Rock	63	07	12.80		10.68	9,018.24	205	11	18.6						
mburg	83	00	41.23		40.83	14,433.69	302	12	16.9						
ssler	33	52	10.16		08.49	16,061.91	88	25	23.8	38	6	32.11	90	34	08.06
			4.19		0.00										
mburg	50	21	21.52		20.73	14,433.69	302	12	16.9						
essler	50	17	47.01		47.58	11,309.11	172	35	19.6						
lune	79	20	51.68		51.68	11,299.44	71	55	33.5	38	42	35.80	90	35	08.44
			00.21		59.99										
amburg	48	58	32.58		31.22	11,299.44	251	50	56.1						
lune	34	54	25.20		26.04	8,573.42	37	01	07.7						
oleman	96	07	03.86		02.74	6,503.13	120	51	51.5	38	38	53.75	90	38	41.90
			1.64		0.00										
amburg	48	30	45.94		44.83	6,503.13	300	49	27.4						
oleman	55	48	08.55		08.09	5,027.52	176	39	59.6						
olfrum	75	41	06.49		07.08	5,551.10	71	20	59.1	38	41	36.52	90	38	54.09
			0.98		0.00										
lune	87	32	01.26		00.51	8,573.42	37	01	07.7						
oleman	35	45	47.83		46.24	10,247.66	252	44	40.5						
oward	56	42	12.38		13.25	5,994.61	129	31	06.8	38	40	32.14	90	31	57.05
			1.47		0.00										
lune	84	23	22.16		22.37	5,994.61	309	29	07.2						
oward	56	35	05.09		05.36	9,474.64	186	06	12.1						
aint Charles	39	01	32.75		32.28	7,946.56	45	08	10.5	38	45	37.66	90	31	15.32
			0.00		0.01										
oward	83	10	40.80		41.47	9,474.64	186	06	12.1						
aint Charles	33	12	06.20		06.77	5,787.62	282	54	31.5						
ee Fee	63	37	10.21		11.75	10,501.60	39	19	46.0	38	44	55.67	90	27	21.71
			57.21		59.99										
aint Charles	76	52	26.08		26.60	5,787.62	282	54	31.5						
ee Fee	60	11	57.87		57.98	8,275.91	163	08	55.7						
arvin	42	55	34.86		35.42	7,374.17	26	03	28.8	38	49	12.52	90	29	01.16
			58.81		0.00										
ee Fee	54	46	49.04		50.49	8.275.91	163	08	55.7						
arvin	68	39	13.63		14.93	8,101.73	274	28	38.5						
harbonnier	56	33	52.04		54.58	9,236.75	87	58	13.7	38	48	51.87	90	23	26.38
			54.71		0.00										
arvin	23	07	30.36		30.70	8,101.73	274	28	38.5						
harbonnier	134	06	25.81		25.36	8,221.97	228	38	33.7						
ommerce	22	46	07.13		03.94	15,032.05	71	27	18.3	38	51	47.98	90	19	10.40
			3.30		0.00										
harbonnier	21	17	53.51		54.24	8,221.97	227	38	33.7						
ommerce	136	29	08.97		07.41	7,898.44	185	10	21.7						
Eagle's Nest	22	12	58.30		58.35	14,972.52	27	23	38.5	38	56	08.07	90	18	40.84
			0.78		0.00										

TABLE I.—*Tabulated results of secondary triangulation, etc.*—Continued.

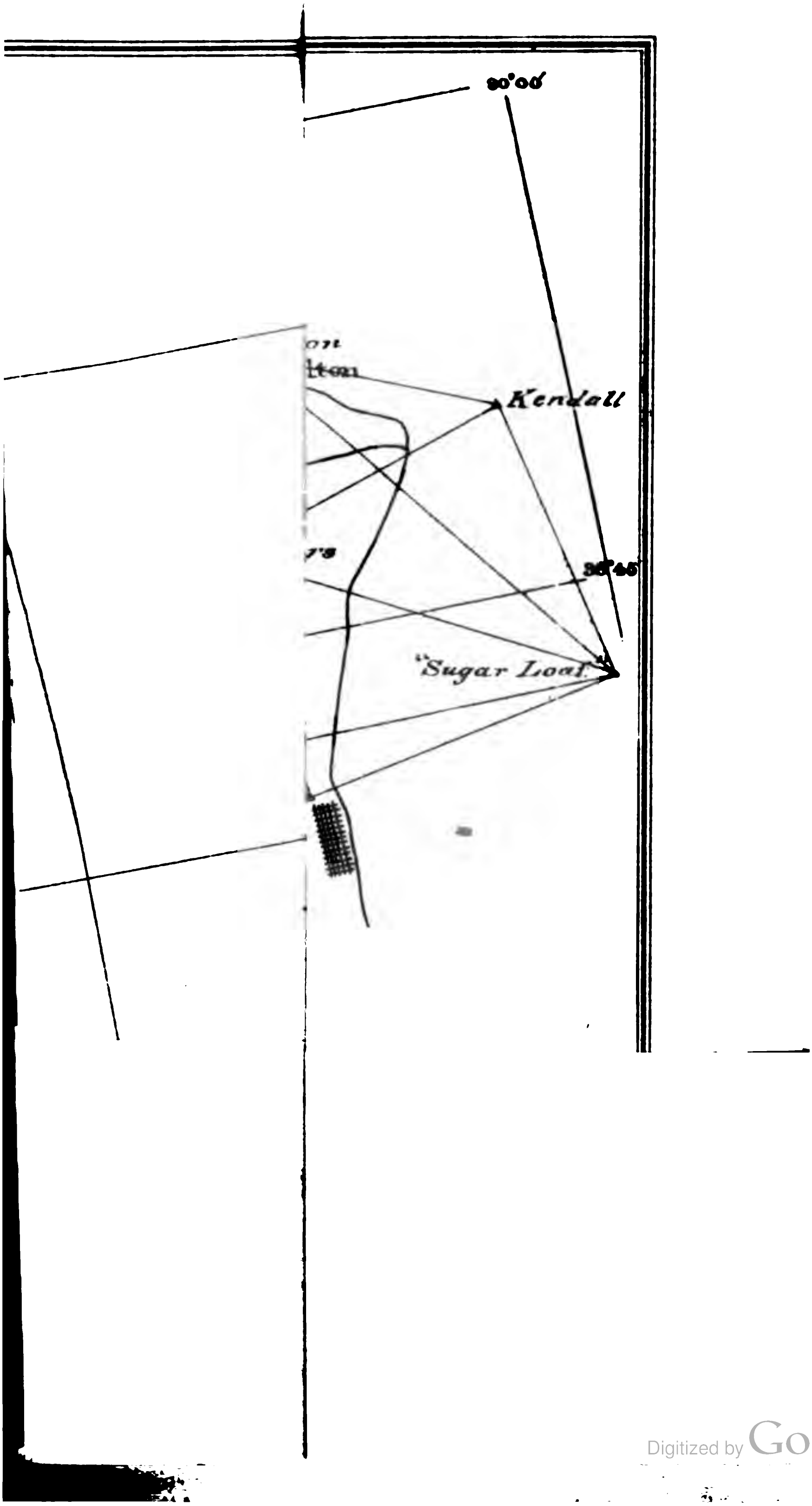
Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
	° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
Commerce	68 50 23.98	21.88	7,898.44	185 10 21.7		
Eagle's Nest	70 26 55.29	53.03	11,292.73	294 43 47.3		
Alton	40 42 45.16	45.09	11,410.99	74 05 29.3	38 53 29.65	90 11 35.24
	4.43	0.00				
Commerce	50 21 25.53	25.17	11,410.99	254 00 43.6		
Alton	57 15 22.59	23.10	10,980.97	16 50 06.2		
Meyers	63 23 12.16	11.73	10,735.18	133 25 31.8	38 47 48.79	90 13 47.[illegible]
	0.28	0.00				
Alton	84 29 47.44	45.71	10,980.97	16 50 06.2		
Meyers	55 09 36.68	34.80	16,883.91	251 58 18.3		
Kendall	40 20 39.77	39.49	13,921.64	112 25 55.1	38 50 37.72	90 02 41.29
	3.89	0.00				
Meyers	46 54 32.33	31.65	16,883.91	251 58 18.3		
Kendall	83 25 49.30	51.10	16,176.12	348 39 24.5		
Sugar Loaf	49 39 35.82	37.25	22,005.51	119 01 09.7	38 42 03.35	90 00 29.62
	57.45	0.00				
Meyers	53 48 33.34	33.47	22,005.51	298 52 50.0		
Sugar Loaf	40 06 54.86	55.92	17,801.42	78 54 13.1		
Water Tower	86 04 29.82	30.61	14,212.13	172 42 10.5	38 40 11.63	90 12 32.22
	58.02	0.00				
Meyers	29 03 23.55	22.71	14,212.13	352 41 23.7		
Water Tower	55 07 58.47	58.47	6,938.04	117 34 12.1		
Minoma	95 48 39.67	38.82	11,721.00	201 42 54.5	38 41 55.69	90 16 46.72
	1.69	0.00				
Minoma	67 37 35.90	35.18	11,721.00	201 42 54.5		
Meyers	82 51 56.89	56.18	22,005.51	289 52 50.0		
Sugar Loaf	29 30 28.65	28.64	23,621.52	89 30 40.5	38 42 03.35	90 00 29.[illegible]
	1.44	0.00				

CONNECTION WITH MORRISON OBSERVATORY.

Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
Dome of Morrison Observatory	57 34	45.00	2,251.78		39 13 45.59	92 49 30.0[illegible]
Stake '85	58 09	45.00	2,110.22			
Glasgow	64 15	30.00	2,123.76	292 05 09.7	39 14 11.49	92 50 52.0[illegible]
Stake '85	117 59	18.00	2,110.22			
Glasgow	28 43	30.00	3,395.26	205 03 31.8		
East Base	33 17	12.00	1,847.91		39 12 31.76	92 51 53.0[illegible]

CONNECTION WITH U. S. ENGINEER'S OBSERVATORY AT FORT LEAVENWORTH, KANSAS.

Stations.	Observed angles.	Adjusted angles.	Distance.	Azimuth.	Latitude.	Longitude.
Observatory Pier	9 12	05.00			39 21 18.03	94 55 02.[illegible]
Stake No. 13	146 04	38.00	1,231.01			
N. E. Base	24 43	17.00	4,296.31	72 56 43.7	39 21 58.93	94 52 11.[illegible]
Observatory Pier	72 11	50.00	4,296.31			
N. E. Base	12 44	57.00	4,106.54			
Azimuth	95 03	13.00	951.82	00 43 04.9	39 21 48.90	94 55 02.[illegible]



90°00′
Kendall
36°45′
"Sugar Loaf"

TABLE II.—*Azimuth observed at △ Glasgow, Mo.*

muth of line △ Glasgow to △ East Base. Instrument: Troughton & Simms's 10-inch theodolite No. 2.]

Observer.	Star, date, etc.	Result for star.			Resulting azimuth.		
		°	′	″	°	′	″
. Merscreau.	Polaris near western elongation, November 9, 1885	25	04	10.44			
Do	δ Urs. Min. near western elongation November 10, 1885	25	04	10.77			
Do	51 Cephei near eastern elongation November 10, 1885	25	04	08.02	25	04	09.74

TABLE III.—*Azimuth observed at △ Azimuth Fort Leavenworth.*

imuth of line △ Azimuth to △ Northeast Base. Instrument: Troughton & Simms's 10-inch theodolite No. 1.]

Observer.	Star, date, etc.	Result for star.			Resulting azimuth.		
		°	′	″	°	′	″
V. Mersereau.	δ Urs. Min. near western elongation October, 7, 1886	265	39	52.33			
Do	δ Urs. Min. near western elongation October 9, 1886	265	39	51.34			
thurst Smith.	Polaris, near eastern elongation October 10, 1886	265	39	52.15			
Do	δ Urs. Min. near western elongation October 10, 1886	265	39	53.58	265	39	52.35

SCRIPTION OF PERMANENT STATION-MARKS, SECONDARY TRIANGULATION BETWEEN SAINT LOUIS AND FORT LEAVENWORTH.

"*Sugar Loaf*" is a U. S. Coast and Geodetic Survey station and was also occupied by the ississippi River Commission. It is 11 miles north of east from Saint Louis and about miles northwest from Collinsville, Ill., on the farm of a Mr. Moore, on an Indian mound, hich, on the bluff, overlooks the valley of the Mississippi River. It is about 100 feet utheast by east from the northwest corner of northeast quarter of northeast quarter of ction 20, township 3 north, range 8 west. The underground mark is an earthenware yramid, 3½ feet below surface, and the surface mark a white marble monument—usual arks of the U. S. Coast Survey.

"*Minoma*" is a Coast and Geodetic Survey station on the residence of Mr. Jefferson K. larke, and is about 7 miles from Saint Louis city hall and one-half mile north of the atural Bridge road in Saint Louis County, Mo. The station is in the center of flag-staff n cupola and near center of cupola.

Water Tower is identical with "stand-pipe" of the Mississippi River Commission, but ot with that of the U. S. Coast Survey. It is on the old water tower of the Saint Louis ater-works, corner of Fourteenth street and Grand avenue. It is the center of a small riangle, cut in iron cap, and the center of the stand-pipe bears north 46° west and is 7.8 eet distant.

Meyers is not identical with the U. S. Coast Survey station, which latter was not permanently marked. It is on higher ground, about 700 feet northwestward, and is about 50 feet southeast from the highest point on land of William Jacobsmeyer. It is near he center of the northwest quarter of southeast quarter of section 21, township 47 north, ange 7 east, Saint Louis County.

Kendall is in Illinois, 75 feet north of the Alton and Edwardsville road, about one-half nile north and one-fourth mile west from the southeast corner of section 36, township 4 orth, range 9 west, at which corner is the railroad station, Wanda. It is on the highest point of the bluff in the apple orchard of a Mr. Kendall.

Alton is nearly identical with that of the Mississippi River Commission, but their nark for the station could not be found. It is in the city of Alton, on the bluff just bove the old penitentiary, in the rear yard of Dr. C. B. Rohland's residence, and about 3 feet from the south edge of the graded flat portion of the yard.

Eagle's Nest is a station of the Mississippi River Commission. It is in Illinois, on the lower part of a wooded bluff ridge, at the head of Eagle's Nest Island, on the land of a Mr. Starr. It is nearly identical with station 28 of Major Simpson's survey.

Commerce is in Saint Louis County, on land known as the James farm, now owned by John F. Reller, of Saint Louis, Mo. It is on the highest part of the highest hill in the vicinity and about 200 feet north from the Douglas road, 1 mile from Musick's Ferry.

Charbonnier is in Saint Louis County, on Charbonnier Point, on land owned by Louis C. Knoepp. It is on an Indian mound and about one-fourth mile from the Missouri River, on comparatively low ground.

Garvin is in Saint Charles County, on land of Alex. Garvin. The knobs are known as the "Mamelles," and the station is on the highest part of the second one in size. It is about one-fourth mile east from Mr. Garvin's brick house.

Saint Charles is about 2 miles southwest from the city of Saint Charles, on land of Herman Witte. It is 150 feet south from the northwest corner of his 47-acre tract and 4 feet from the west line of said tract.

Fee-Fee is in Saint Louis County, about one-eighth mile northeast from the orchard of William Blackwell. It is in an open field, on comparatively low ground.

Howard is in Saint Louis County, about three-fourths of a mile west from Lake post-office, and 400 feet north of the Olive street road. It is about 100 feet north from the old barn, and on the highest part of the high ridge.

Klune is in Saint Charles County, on land of a Mr. Klune. It is near the edge of a wooded bluff and a cut stone monument stands alone in an open field, about one-eighth mile back on the ridge.

Wolfrum is in Saint Charles County, on land of John N. Wolfrum, and opposite the middle of Post's Island. It is about 75 feet back from a perpendicular rock bluff, in a cleared field.

Hamburg is one mile below the town of Hamburg, on the center one of three prominent bluffs. It is within 60 feet of the edge of a perpendicular rock bluff, in a cleared field of Adam Iman, and is 12 feet in front of an old log-house.

Coleman is in Saint Louis County, one mile northeast from Orrville post-office, on land of the Frederick Koeving estate. It is on the highest part of the highest hill in the vicinity, and near evergreen trees and burial monuments. It is one-fourth mile east from Dr. Robert G. Coleman's residence.

"*Kessler*" is a U. S. Coast and Geodetic station, about 2 miles northwest from Baldwin, Mo., on land of J. F. Kessler. It is at the intersection of roads and in the northwest angle on the highest ground in the vicinity.

Wild Horse is in Saint Louis County, on land of a Mr. Tyler, on an Indian mound on the wooded bluff, one-half mile east from the residence of Jacob Bailey. It is 50 feet north from the angle in the Wild Horse Creek road.

"*Tavern Rock*" is a U. S. Coast and Geodetic Survey station on the highest part of the Tavern Rock Bluff in Franklin County, 1 mile west from Saint Louis County. It is on land of Charles Foley and is 470 feet northwestward from the northwest corner of his house.

Parsons is in Saint Charles County, on land of a Mrs. Parsons, opposite Tavern Rock. It is on the highest part of a rocky, wooded knoll and just north of the road, and is about one-half mile north from Mrs. Parson's brick residence.

Need is in Saint Charles County, opposite Tavern Rock, on a high wooded ridge. It is about one-half mile back from Mr. Oberdick's house.

Engel is in Saint Charles County, 2½ miles below Augusta, on a prominent perpendicular bluff on land of William Engelager. It is on the highest point of the bluff.

"*Dieckhaus*" is a U. S. Coast and Geodetic station in Saint Charles County, about 1½ miles east from its west line, which west line is on the fifth principal meridian. It is in the northwest quarter, section 8, township 44 north, range 1 east, on a rocky, wooded, high ridge, on land of a Mr. Dieckhaus. The surface stone, being broken, was replaced by an iron pipe of the Missouri River Commission.

Meyer is in Franklin County, in northwest quarter, section 21, township 44 north, range 2 east, about 1 mile above the mouth of Fiddle Creek, on land of A. W. Meyer, on a northern summit of the high ridge. It is 15 feet east from the Meyer's private burial ground.

Ming is in Franklin County, in fractional section 28, township 44 north, range 1 east, on land of Judge Ming, and about one-half mile east-northeast from his residence. It is just inside the cultivated field, and the road is between it and the nearly perpendicular bluff.

"*Halleck*" is a U. S. Coast and Geodetic station on the north side of the rock road in Franklin County, on the highest part of the highest hill in the vicinity of Mount Halleck post-office. It is 68½ feet from the northeast corner, and 67 feet from the northwest corner of Mr. Breitenbach's store.

Noelker is on Noelker's Hill, about 1 mile west-southwest from Washington, Mo.

Bearings at △ Noelker: Southeast corner northwest quarter, section 21, township 44 orth, range 1 west, equals south 48° east, distance about 1,200 feet. First reference ree (white oak), south 86° west, 24.6 feet; second reference tree (white oak), north 8° ast, 11 feet.

Tuque is in Warren County, three-fourths of a mile below Marthasville, on an Indian ound, on land of Mrs. Schurmann, and is near her west line. It is on the first bluff bove Tuque Creek.

Dundee is in Franklin County, on the projecting bluff, 1¾ miles below Dundee, on land f S. A. Chitwood, and about 200 paces north of his residence. It is in northwest frac-onal quarter of section 1, township 44 north, range 2 west.

Emily is in Warren County, on land of Frederick Hellbrusen, on an Indian mound, on comparatively low-wooded ridge, back of Emily Bend, and about three-fourths of a mile outh of Concord.

"*Enoch Knob*" is in Franklin County, on the well-known knob, 1 mile south of Dundee. t is a U. S. Coast and Geodetic station on the highest part of the rocky knob.

Maupin is in Franklin County, on a county cemetery lot of 2 acres. It is on an Indian ound, just east of the Maupin burial lot.

"*Berger*" is a U. S. Coast and Geodetic station, 4 miles south of west from New Haven, n the summit of the highest hill in the vicinity. It is reached from New Haven by a air wagon-road.

Etlah is in Franklin County, on land of M. D. Rees, on a prominent Indian mound, hree-quarters of a mile below Etlah railroad station.

Kellner is in Franklin County, on land of G. Kellner, on the point of bluff, three-uarters mile below Boeger railroad station.

Hermann is on the highest part of the high wooded bluff, three-quarters mile southeast rom Hermann, Mo. The land is owned by the Hermann Savings Bank. The stone, arking the center of northeast quarter section 31, township 46 north, range 4 west, is 82 feet to the left of the line △ Hermann △ Red, at right angles from a point on this 74.5 feet from △ Hermann.

School is in Warren County, on a hill known as School Hill, in the southwest quarter ection 11, township 45 north, range 3 west. The station is on an Indian mound on the ighest part of this prominent peak.

Lost is in Warren County, 1½ miles below Lost Creek. It is on about the highest per-endicular rock bluff in the vicinity, on land of Christian Sundermeyer; a large walnut ree, with stones piled around its roots, is 8 feet south of the station.

Red is in Warren County, about 1 mile north from the red bridge over L'Outre lough, on land of J. Conzleman and on top of the hill and just west of the road. The outheast corner of northeast quarter section 18, township 46 north, range 4 west, bears outh 6° 06′ east and 278 feet distant.

Bolan is in Montgomery County, on Bolan's Knob, about 6 miles northwest from Iermann. It is on the south point of the prominent bluff.

Miller is in Montgomery County, in northeast quarter section 33, township 46 north, ange 6 west. It it is on the point of the high wooded bluff 2 miles below Bluffton, on and of Thomas Powell.

Bluffton is in Montgomery County, about 700 feet east from the west county-line, 1½ niles above Bluffton, on the highest part of the bluff between two uninhabited houses.

Fey is in Gasconade County, on land of Jacob Fey, in northwest quarter of south-vest quarter section 6, township 45 north, range 5 west. It is on the north end of the idge in a cleared field. The southeast corner of Mrs. Neuenhahn's fractional 20 acres f land bears south 74° west, and distant 108½ feet.

Morrison is in Gasconade County, 1 mile south of Morrison, on land of Lorenz Straub, n the highest part of his farm. It is on a knoll between the house and barn.

Townley is in Osage County, in east half northeast quarter section 8, township 45 north, ange 7 west. It is on an Indian mound, on the highest point of the wooded hill and bout 225 feet south from the section line, on land of Mrs. J. W. Townley.

Chamois is about 2 miles west from Chamois, Mo., on an Indian mound, on the highest art of the bluff. It is on land of James Robinson, in northeast quarter of northwest uarter of section 15, township 45 north, range 8 west.

Saint Aubert is in Osage County, on a high point of bluff, about one-half mile above Saint Aubert railroad station. It is 227 feet east and 338 feet north from the north-west corner of the southwest quarter section 19, township 45 north, range 8 west.

Isbell is in Osage County, near the center of section 4, township 44 north, range 9 west, on land of Mrs. Perrigee. It is about 15 feet east of the rock-cut road, and 100 feet north of the gate.

Osage is in Osage County, on the second spur of bluffs east of the Osage River railroad bridge, on land of Benjamin Johnson. It is 4¼° west of north, and 21 feet distant from

a blazed hickory, 60½° east of north, and 45 feet distant from a blazed maple, and 3° west of south, and 46 feet distant from a large maple stump.

Portland is in Callaway County, 1 mile above Portland; in southwest quarter section 32, township 46 north, range 7 west, on land of Adolph Tomek. It is on top of a hill in an open field and near the southeast corner of the vineyard.

Harrison is in Callaway County, on a high ridge of the Harrison tract, 1 mile above Auxvasse River. The nearest corner of the old tobacco house bears south 85½° east, distant 95 feet, and an old cistern bears north 58° west, distant 12 feet.

Bagby is in Callaway County, about one-half mile south from the Bagby school-house, on land of Benjamin Moseley. It is north 39′ west, and distant 437 feet from the southeast corner of northwest quarter section 23, township 45 north, range 9 west.

Pres is in Callaway County, in southwest quarter section 31, township 45 north, range 9 west. It is near High Hill Church, on land of "Pres." Warfield. It is south 31½° east, and distant 26 feet from the southwest corner of the hen-house, and south 8° east, and distant 27 feet from the southeast corner of the same.

Agent is in Callaway County, in the southeast quarter section 3, township 45 north, range 10 west, on land of a coal company, C. Renshaw, agent, and is about 1 mile south of John Farmer's residence. It is on the highest point of the wooded hill.

"*Cedar*" is a U. S. Coast and Geodetic survey station, 2¼ miles northeast from Jefferson City, on the highest hill in the vicinity. It is in the center of an Indian mound on the highest point.

Ewing is in Cole County, near Ewing railroad station, in the garden of George A. Walthers, and about 400 feet from the Missouri River.

Ulrich is about 2 miles southwest from Jefferson City, on the highest hill in the vicinity in the dooryard of Ulrich Zehendner. It is 45 feet east and 340 feet south from the northwest corner of the northeast quarter of the northwest quarter section 24, township 44 north, range 12 west.

"*Medlock*" is a U. S. Coast and Geodetic Survey station, on land of L. M. Chambers. The northwest corner of section 22, township 45 north, range 13 west, bears north 2° 35′ west, and distant 909 feet from the station.

Marion is in Cole County, and about 1½ miles from its western line. It is 1¼ miles above Marion, in the common between the road and bluff, and 100 feet from the edge of the bluff on the highest point in the vicinity.

△ *Quinn* is in Boone County, in the southwest quarter section 24, township 46 north, range 12 west, on land of J. C. Madden. It is on the highest point in the peach orchard 120 feet east of the road and 200 feet south of the old barn.

Griffin is in Boone County, just west of the thirteenth range line and about 1,000 feet south of the northeast corner of section 1, township 45 north, range 13 west. It is on a wooded knob, about one-half mile southwesterly from W. H. Griffin's residence.

Wright is in Boone County, on the highest point back of Judge H. T. Wright's residence. It is in the southeast quarter section 15, township 46 north, range 13 west.

Providence is about three-quarters of a mile below Providence, Mo., on an Indian mound, on the highest point in the vicinity. It is in the northwest quarter section 28, township 47 north, range 13 west, on land of J. Jeffrey.

Warren is in Boone County, in the northwest quarter section 17, township 47 north, range 13 west. It is 150 feet north of the road from Providence to Rocheport, on the highest ground in the vicinity of Mr. S. W. Warren's residence, on land of A. Ballinger.

Fisher is in Moniteau County, in the northeast quarter section 2, township 46 north, range 14 west, on land of F. W. Fisher. It is on an Indian mound, on the highest ground in the vicinity of Mr. Fisher's house.

Denton is in Moniteau County, in the southwest quarter section 23, township 47 north, range 14 west, on land of the Denton estate. It is on an Indian mound, the second in size on the wooded ridge.

Mount Vernon is in Moniteau County, in the southwest quarter section 32, township 48 north, range 14 west, on land of James Vaughn. It is on the highest part of the cultivated field, and about 200 feet from the road.

Hopkins is in Cooper County, in the southwest quarter section 14, township 48 north, range 15 west, on edge of bluff, about one-eighth of a mile north of Mr. H. B. Hopkins' residence.

Aux is in Cooper County, on land of Joseph Kickershear, near the center of section 9, township 48 north, range 15 west. It is about 100 feet northwest from the large Indian mound.

Hays is in Cooper County, in the northwest quarter section 5, township 48 north, range 15 west, on land of G. W. Hays. It is on an Indian mound, on the highest ground, about 400 feet east of Mr. Hays' barn.

Searcy is in Boone County, in the southeast quarter section 21, township 48 north, range 14 west. It is on the second Indian mound from the road, between the road and perpendicular bluff, on the land of the W. C. Searcy estate.

Rocheport is one mile east of Rocheport, Mo., on land of E. D. Beyers. It is on a low Indian mound in an orchard, and about 200 feet south of the road.

Farris is in Howard County, in northeast quarter section 31, township 48 north, range 15 west, on land of Jack Farris. It is on the middle one of three Indian mounds on the prominent peak.

Chapel is in Howard County, 153 feet south and 1,025 feet east of the northwest corner of section 36, township 49 north, range 17 west. It is on the highest Indian mound, just west of the grove of Clark's Chapel.

Hayter is in Howard County, in the southeast quarter section 20, township 49 north, range 17 west. It is 83 feet west of the road, on the highest of the several Indian mounds, on land of A. J. Hayter. A gas-pipe, set in cement, marks the station.

Lisbon is in Howard County, 2 miles below Lisbon, on land of Price Cooper, about 300 feet south, 48° east from his house. A gas-pipe, set in cement, marks the station.

Combs is in Cooper County, in the northwest quarter section 4, township 48 north, range 16 west, on land of James Combs. It is in the orchard, 3 feet south from the road fence, and 6.7 feet east of the door-yard fence.

Boonville is about one mile above Boonville, Mo., on the prominent Indian mound near the northwest corner of the water-works reservoir. A gas-pipe, set in cement, marks the place of station.

Lamine is on land of William Emmons, about 1 mile above the mouth of the Lamine River. It is on a prominent Indian mound, between the road and bluff, and a gas-pipe, set in cement, marks the place of the station.

Arrow Rock is about three-fourths of a mile below Arrow Rock, on land of D. Lawless. It is in the northeast corner of the peach orchard, and a gas-pipe, set in cement, marks the place of the station.

Saline is in Saline City, in Second street, one block above Main street. It is 484 feet east and 261 feet north from the southeast corner of northeast quarter section 1, township 50 north, range 19 west. A gas-pipe, set in cement, marks the place of the station.

Aid is in Saline County, about 2 miles north of Saline City, on land of James Duncan. It is on the highest part of the ridge, 92 feet northeast from the northeast corner of the log house.

Duncan is in Saline County, on land of the Duncan estate, now owned by W. M. Wilhite. It is 14 feet north and 681 feet east of the southeast corner of northeast quarter section 13, township 51 north, range 19 west. It is marked by a gas-pipe, set in cement.

Crowley is in Howard County, on land of Benton Crowley. The northwest corner of the southwest quarter section 13 bears north 39° 15′ west, distant 216.5 feet. It is on the highest part of an open field.

Bluffport is in Howard County, on a prominent Indian mound, just below Bluffport Landing. It is marked by a gas-pipe, set in cement.

Glasgow is three-quarters of a mile above Glasgow, Mo., on an Indian mound, at the end of a very sharp ridge, and about 300 feet from the river. It is marked by a gas-pipe, set in cement.

East Base (*Glasgow*) is in Saline County, about 1 mile below the Chicago and Alton Railroad Bridge, on land of Mr. Cook, and the base line is through his door-yard. The station is 1,500 feet south 67½° east from the southwest corner post of the picket fence of Mr. Cook's door-yard.

West Base (*Glasgow*) is north 67° 26′ 10″ west and 7,923 feet distant from station East Base. It is on south side of Chicago and Alton Railroad track, between the track and the fence, 8 feet from the fence and 200 feet west of the side track.

Cambridge is in Saline County, in the southwest quarter of the southwest quarter section 26, township 52 north, range 19 west. It is on the highest part of an open field, 20 feet east of the road from Cambridge to Gilliam. It is marked by a gas-pipe, set in cement.

Bender is in Chariton County, in the northeast quarter section 13, township 52 north, range 18 west, on land of Peter Bender. It is on a bluff, about 100 feet north of the Keytesville road, and opposite residence of Carl Klahn.

Bluff Rock is in Chariton County, on land of Simeon Hunt, one-eighth of a mile below "Bluff Rock" on the Chariton River. It is in an open clearing and 50 feet back from the edge of the bluff.

Dalton is in the village of Dalton, near the colored church. It is north 70° west from the northwest corner of the church and 105 feet distant; also south 80° west, distant 67 feet from a survey stone mark.

De Witt is one-half mile southwest of the village of De Witt, on land of Hiram Jaqua, on the highest ground in the vicinity. It is south 56° east, and distant 414 feet from the northwest corner of southwest quarter, northeast quarter section 26, township 53 north, range 21 west.

Brunswick is in the village of Brunswick, on the highest point in vicinity of the public-school building. It is 4½ feet southwest of the southeast corner of Keyte's addition to the town of Brunswick.

White Rock is three-eighths of a mile north of the stone quarry at White Rock, on land of D. F. Estes. It is on a large Indian mound, 40 feet from the blacksmith-shop.

Frankfurt is in Saline County, in angle of road one-fourth of a mile northerly from "Good" Hope church. It is on the north and south line, separating the twenties of the southeast quarter of the southwest quarter of section 16, and 300 feet south of the north line of said twenties, township 52 north, range 19 west.

High Hill is in Saline County, near the High Hill Cemetery, on land of Judge Winning. It is on the ridge, 15 feet south and about 700 feet west from the northeast corner of the northeast quarter of the southeast quarter of section 11, township 52 north, range 20 west.

Hawkins is in Saline County, in the southeast quarter, northeast quarter section 26, township 53 north, range 21 west, on land of Walter Hawkins. It is on an Indian mound, in an open field and on the highest ground.

Longview is in Saline County, in the northwest quarter, northeast quarter section 16, township 52 north, range 21 west, on land of S. J. Zink, and is about 100 feet northwesterly from his dwelling.

Marshall is in Saline County, about 3 miles above Miami, Mo., on land of Mrs. Van Meter. It is on an Indian mound, on a wooded ridge, and near the Laynesville road.

Malta is in Saline County, 565 feet north and 95 feet west of the southeast corner southwest quarter section 4, township 51 north, range 22 west, on land of G. A. Renick. It is on the highest point in an open field.

Gilham is in Saline County, near the center of the southwest quarter, southeast quarter section 7, township 51 north, range 23 west, on land of W. W. Earp. It is on the most prominent Indian mound on the wooded hill.

Wakenda is in Carroll County, about one mile north of Wakenda railroad station, on land of William Carey. It is on an Indian mound, on the highest bluff, in the vicinity and just north of the road fence.

Carrollton is on the westerly of two Indian mounds, about 450 feet west of the cemetery at Carrollton, Mo.

Norborne is in Carroll County, in the southwest quarter southeast quarter section 10, township 52 north, range 25 west, on land of John Dietrich. It is on the extreme south point of the bluff.

Carroll is in Carroll County, on the point of a ridge, 264 feet northeasterly from the southwest corner of the northwest quarter northeast quarter section 18, township 52 north, range 25 west, on land of A. J. Green.

Doris is in La Fayette County, in northwest quarter section 18, township 51 north, range 24 west, on land of David H. Davis. It is on a prominent Indian mound on the narrow ridge, just above a projecting rock, known as Sheep Nose Rock.

Dover is in La Fayette County, in the northeast quarter southwest quarter section 9, township 51 north, range 25 west, on land of Mr. Webb. It is about one-half mile below Spruel's saw-mill, on the last Indian mound toward the northeast point of the bluff.

Sheep's Nose is on the prominent bluff by that name, about 2 miles above Berlin, on land of Stephen Lamar. It is on an Indian mound, 8 feet north of the house, and 24 feet west of the section line, between sections 21 and 22.

Lexington is near the north end of Ash (or Sixteenth) street. It is south 35° east, distant 330 feet from a stone in this street, which is supposed to mark the center of section 27, township 51 north, range 27 west.

Odell is in La Fayette County, in the southeast quarter southeast quarter section 5, township 50 north, range 28 west. It is in the center of a very large Indian mound, on the highest point in the vicinity, on land of G. T. Odell.

Wellington is about 2 miles above Wellington, Mo., on land of William Course. It is near the extreme north end of the wooded ridge.

Help is in Ray County, about 1½ miles northerly from Lexington Junction railroad station, on land of G. W. McGaugh. It is in the apple orchard between the house and nearly perpendicular bluff.

Junction is in Ray County, in the apple orchard of David Hixon. It is south 450 feet and east 120 feet from the northwest corner of section 8, township 51 north, range 27 west.

Camden is just north of the town limits of Camden, Mo., on land of John Sacry. It is 157 feet north and 602 feet east of the southwest corner of section 23, township 51 north, range 28 west.

Ralph is in Ray County, 9 feet north and 87 feet east of the southwest corner of southeast quarter northeast quarter section 29, township 51 north, range 28 west, on land of Mr. Ralph.

Orrick is in Ray County, in the southeast quarter section 14, township 51 north, range 29 west. It is on a wooded ridge, about 1½ miles north from Orrick railroad station.

Hudson is in Jackson County, in the northwest quarter section 11, township 50 north, range 30 west, on land of Mr. Hudson. It is on the highest point of the highest knob in the vicinity, and overlooks the country for 20 miles around.

Little Blue is on the bluff at the mouth of the Little Blue River, on land of Park Dixon. A maple tree bears south 51° west, 29 feet distant, a maple tree bears north 68½° one-half west, 49 feet distant, and a mulberry tree bears north 40° east, 18 feet distant from the station.

Blue Mills is in Jackson County, in the northeast quarter northeast quarter section 8, township 50 north, range 31 west, on land of Daniel Lynch. It is on the ridge to the north of the house, and a large linn tree is northeast 15 feet distant.

Cooley is in Clay County, about three-fourths mile back from bluffs known as Cooley's Point, on land of Mrs. Cordelia Elitzer. Philip Elitzer's house bears north 60° west, distant 450 feet. It is 20 feet north from a line fence.

Missouri City is on lot No. 4 of this city. It is about 90 feet from the southwest corner of the house of Mrs. Corwine, to whom the lot belongs.

Saint Bernard is on a bluff known by this name, on land of Mr. Carney. It is about one-eighth mile below railroad trestle, and 45 feet west of a section line fence.

Wayne is about one-fourth mile below Wayne City, on the prominent bluff, and between the road and edge of bluff. It is 6 feet east of the Indian mound and 25 feet north of the center of the road.

Kansas City is in the eastern part of the city on a vacant lot of Campbell's Third Addition, east of Wabash street and north of St. Johns street, on the highest part of the bluff.

Buster is in Clay County, 275 feet north and 75 feet west from the southeast corner of northeast quarter section 4, township 50 north, range 32 west, on land of Charles E. Buster. It is on the ridge and just south of the fence of the door yard.

Todd is in Clay County, south 82½° west, and distant 707 feet from the northeast corner of section 3, township 50 north, range 33 west, on land of Mr. Todd. It is on the ridge just east of the private road.

Quindaro is on ground known as "University land" at Quindaro, Kans. It is north 87° west and 135 feet distant from the northwest corner of the stone university building, 54 feet east of the hedge fence, and about 375 feet north, 27½° east of the stone school-house for negroes.

Carpenter is in Platte County, about 1½ miles northeast of Parkville, on land of Doctor Carpenter. It is on the highest land in the vicinity, between the ruins of an old house and the road. It is 45 feet from the westerly of two chimneys and 50 feet from the easterly.

Parkville is three-fourths of a mile northwest of Parkville, on land of Daniel (brothers). It is on the high, naked ridge, 14 feet in front of the log barn.

Tanks is 2 miles below Pomeroy, Kans., on the highest part of an open field, one-half mile back from the railroad water-tanks.

Connors is three-fourths of a mile above Connors, Kans., in an open field, 1,000 feet back from edge of bluff and about 1,000 feet east from the walnut grove of John Sink.

Waldron is about 1 mile southeast of Waldron, Mo., on land of Mr. Havelow. It is on the highest point of a cultivated field, and about one-eighth of a mile southwesterly from Mr. Havelow's house.

Spinner is in Platte County, in the southwest quarter of southwest quarter section 21, township 52 north, range 35 west, on land of Charles Knapp. It is on a mound on the second wooded hill east from Joseph Spinner's residence.

Delaware is about 1½ miles east of Lansing, Kans., on land of John Veneman, on the bluff just below Delaware railroad station. It is 4 feet east of the corner post of a barbed-wire fence.

Reservoir is 10 feet east of the east gate of the high plank circular fence of the Leavenworth water-works reservoir, and 23 feet from stone wall of reservoir.

Hellman is in Platte County, on land of J. G. Hellman, on a bluff 1½ miles south of Beverly, Mo. It is between the house and road on the highest point, and 36 feet southwest from the southwest corner of the log house.

Weston is about one-half mile below Weston, Mo., on the second bluff from the town. It is on the highest point, about 100 feet south of the corner of the board fence.

Sheridan is on the most prominent Indian mound, at the north end of "Sheridan Drive," 2 miles northwest of Fort Leavenworth, Kans. It is about 100 feet from the extreme north end of the ridge.

Azimuth is in the northeast corner of a cultivated field, about one-half mile north of the parade grounds of Fort Leavenworth. It is on the crown of the hill between the private road and fence.

S. W. Base is in Missouri, opposite Fort Leavenworth, at the curve in the track of the Chicago and Rock Island Railroad, about 1 mile easterly of the railroad bridge. It is on the south side of the railroad track, and 3 feet westerly from the line of the westerly rail from Beaverly, if produced in a straight line. It is 30 feet from the northeast corner of the 60-foot trestle, and the northeast corner of U. S. Military Reservation is 63 feet to the right of a point on the line towards △ Azimuth, at a distance of 195 feet from △ Southwest Base.

N. E. Base is 1,300 feet northerly from the railroad junction at Beverly, Mo. It is 20½ feet northerly from the center of the railroad track, and 64 feet southerly from the intersection of the wagon-roads.

BRIDGE REQUIREMENTS, MISSOURI RIVER COMMISSION.

[Extract.]

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., April 1, 1886.

GENERAL: The copies of House bills 2838, 4793, and 6356, and Senate bills 985 and 1123, herewith returned, have been submitted to the Missouri River Commission for an expression of their views thereon, as requested in your indorsements on the inclosures.

Passing by for the present some minor criticisms on the bills under consideration, the Commission decide that for bridges above Kansas City no spans of less width than 300 feet should be allowed over the water-way of the river. In the case of a low bridge a clear opening of this width is imperative, and unless it can be given no low bridge should be allowed. A clear height of 50 feet, measured from extreme high-water mark to the lowest part of the superstructure, is required in the case of a high bridge, and 10 feet for a low bridge. The piers in all cases should be parallel to the current, and the axis of the bridge as nearly as possible at right angles thereto. The channel-opening in low bridges and the channel-span in high bridges should have the required width of 300 feet at all stages of the river. No riprapping around piers should be allowed in any case, or any other substitute for imperfect foundations which will sensibly contract the water-way.

These requirements, especially as regards the width of spans, are dictated by a consideration of the peculiar characteristics of the Missouri River. The velocity of its current is so great at all stages as to render unusual precautions necessary to prevent bridges erected over it from unduly obstructing navigation. Any undue contraction of water-way not only materially increases the velocity of current through the bridge, but also gives rise to eddies and cross-currents, which render its passage hazardous as well as difficult. In the various bridge charters passed by Congress the fact seems to have been lost sight of that the greater or less elevation of the superstructure of a bridge does not alter its relation to the free flow of water between its piers. Yet, in the case of high bridges, widths between all piers of 300 feet, or more, are invariably required, while in low bridges widths of 160 feet, or less, are allowed, and only one or two of the spans are required to be from 200 to 300 feet wide. Even in this last case the provision was only introduced to allow the passage of rafts, and had no reference to the clear water-way. Moreover, on the Missouri River bridge sites are invariably chosen at narrow sections, where the contraction of water-way becomes a matter of great importance. Again, in the case of high bridges all spans over the water-way are generally required to give clear widths of 300 feet and 50 feet clear height. In case of necessity any of these openings can be used by boats, but in the case of a low bridge only two openings are available having widths of but 160 feet, and as a matter of fact it is very rare that more than one of these can be used. Hence, if a boat fails to enter one of these narrow openings disaster is certain. A moment's reflection will show that the distinction thus set up is entirely arbitrary and has no support in reason or fact. These recommendations of the Commission are designed to make the requirements in all cases harmonious and sufficient for the purpose intended, viz, the protection of the navigation interests.

* * * * * * *

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers,
President Missouri River Commission.

Brig. Gen. JOHN NEWTON,
Chief of Engineers, U. S. A.

EXPENDITURES.

SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO FORT BENTON, MONTANA.

[Act passed August 2, 1882.]

July 1, 1886, amount available of above appropriation	$2,506.63
Unpaid liabilities, June 30, 1886	80.00
	2,586.63

Itemized expenditures from July 1, 1886, to June 30, 1887, both dates inclusive:

Wages	$1,963.66
Traveling expenses	175.80
Stationery	33.18
Chemicals	11.26
Subsistence stores	266.80
Rope and blocks	87.30
Transportation	40.30
Telegrams	8.33
	2,586.63

OFFICE EXPENSES, TRAVELING EXPENSES, AND SALARIES OF COMMISSION.

July 1, 1886, amount available of above allotment		$761.68
Amount received by transfer from allotment:		
For purchase of tow-boat	$23,900.00	
For Parkville, Mo	1,100.00	
		25,000.00
Received from sales of fuel to officers		182.96
Unpaid liabilities June 30, 1886		438.82
		26,383.46

Itemized expenditures from July 1, 1886, to June 30, 1887, both dates inclusive:

Office rent	$1,450.00	
Telephone	125.00	
Ice	20.90	
Awnings	19.50	
Gas	17.70	
Water	20.00	
Glass, reglazing	7.40	
Boxes, file	43.00	
Fuel	580.06	
Mileage	782.96	
Wages	9,056.73	
Traveling expenses	251.45	
Transportation of employés	40.00	
Stationery	452.26	
Newspaper subscription	13.20	
Telegrams	11.57	
Transportation	12.50	
Office furniture	33.25	
Sundries	141.48	
Lumber	82.42	
Sash (window)	13.00	
	13,174.38	
Unpaid liabilities June 30, 1887	75.93	
Amount expended during fiscal year		13,250.31
July 1, 1887, amount available		13,133.15

ADDITIONAL SURVEYS AND ESTABLISHMENT OF PERMANENT BENCH-MARKS BELOW SIOUX CITY.

July 1, 1886, amount available of above allotment		$502.72
Amount received by transfer from allotment for Parkville, Mo.		23,000.00
		23,502.72

Itemized expenditures from July 1, 1886, to June 30, 1887, both dates inclusive:

Wages	$18,084.68	
Subsistence stores	1,747.98	
Fuel	265.09	
Instruments	22.50	
Instrument repairs	51.30	
Traveling expenses	172.00	
Privilege of felling trees	116.00	
Outfit of fleet	1,650.18	
Stationery	15.25	
Engineers' supplies	15.49	
Medicines	14.10	
Skiffs	316.50	
Transportation	244.65	
Drayage	8.00	
Lumber for ways	89.70	
Target repairs	27.85	
Lumber	29.14	
Telegrams	4.62	
Oakum	8.75	
		22,883.78
July 1, 1887, amount available		618.94

PRESERVATION AND OBSERVATION OF GAUGES AND COLLECTION AND COMPILATION OF PHYSICAL DATA.

July 1, 1886, amount available of above allotment		$1,440.33
Unpaid liabilities June 30, 1886		1,090.40
Amount received by transfer from allotment "for Parkville, Mo."		12,000.00
Total		14,530.73

Itemized expenditures from July 1, 1886, to June 30, 1887, both dates inclusive:

Wages	$8,488.27	
Repairs of gauges	135.50	
Stationery	104.76	
Traveling expenses	18.45	
Lubricator	3.60	
Stereotype plates	42.37	
Telegrams	1.07	
	8,794.02	
Unpaid liabilities June 30, 1887	17.33	
		8,811.35
July 1, 1887, amount available		5,719.38

PURCHASE OF TOW-BOAT.

July 1, 1886, amount available of above allotment		$23,900.00
Amount transferred to allotment for office expenses, traveling expenses, and salaries of Commission		23,900.00

OFFICE EXPENSES AND EXPENSES OF COMMISSION.

[Sioux City, Iowa, to Fort Benton, Montana.]

July 1, 1886, amount available of above allotment	$1.57	
Unpaid liabilities June 30, 1886	46.10	
Amount received from Lieut. W. L. Fisk, Corps of Engineers	3.00	
		$50.67
Itemized expenditures from July 1, 1886, to June 30, 1887, both dates inclusive:		
Wages	45.00	
Newspaper subscription	1.10	
Stationery	4.57	
		50.67

SPECIAL SURVEYS (AT OMAHA, ATCHISON, FORT LEAVENWORTH RESERVATION, ARROW ROCK, PLATTSMOUTH, BROWNVILLE, AND NEBRASKA CITY).

[Appropriation of August 5, 1886.]

Total allotment		$10,000.00
Itemized expenditures from July 1, 1886, to June 30, 1887, both dates inclusive:		
Wages	$7,115.84	
Subsistence stores	117.16	
Fuel	34.50	
Traveling expenses	95.97	
Repairing instruments	66.30	
Cotton cloth and tacks	10.12	
Stationery	13.57	
Transportation	29.25	
Chemicals	10.60	
Telegrams	.95	
		7,494.26
July 1, 1887, amount available		2,505.74

APPENDIX A1.

REPORT OF MR. D. W. WELLMAN, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *January* 20, 1887.

SIR: I have the honor to submit herewith report of operations in the field on the portion under my charge of the survey of the Missouri River during the season just past, including the months of September, October, November, and December, 1886.

On September 4th I received your verbal orders to proceed to Kansas City and prepare quarters for three field parties to be organized for the continuation of the survey, commencing at Fort Leavenworth, Kans., and working towards Glasgow, Mo., where similar work was begun in the autumn of 1884.

The quarters were to be built on 16 by 64 feet barges, arrangements for the use of which had already been made from your office with Major Livermore, Corps of Engineers, then in charge of improvements at Kansas City; two of the barges to be fitted up for triangulation work and one for permanent bench-mark work.

I left Saint Louis on the evening of the 5th, reaching Kansas City the next morning. I immediately called on Major Livermore, and learned that one of the barges would be ready in a day or two, but that the other two could not probably be had before the 14th, they being then on shore and behind some others that must first be repaired and put into the water.

A foreman, engaged in Saint Louis, arrived on the morning of the 7th, and the day was spent in perfecting plans, making bills of lumber, and selecting a place for doing the work, which was in the Kaw River near its mouth.

On the 8th, one of the barges was delivered, and proposals were invited from two lumber firms, one in Wyandotte and one in Kansas City, for lumber for cabins on two of the barges. The bid of the Chicago Lumber Company, Wyandotte, was $146 less than that of the Kansas City firm, and, they agreeing also to furnish all that would be required at the prices named in their bid, it was accepted.

In the mean time carpenters had been engaged, and work was commenced on the 9th, and from that time on was pushed as fast as material and workmen could be procured. The second barge was delivered on the 16th, and the third on the 18th.

By the end of the month the cabins were practically completed, they requiring only some inside finishing, such as shelving, tables, benches, etc. October 4, all the carpenters, except the foreman, who was to accompany the survey, were discharged.

The cabins were painted two coats of white outside and one inside. The painting was done by laborers engaged for the survey.

The cabins of the triangulation boats were each 50 by 13 feet, a guard space of 18 inches being left on each side. They each had sleeping accommodations for 20 persons. The cabin on that designed for the bench-mark party was 52 by 16 feet and had sleeping accommodations for 26 persons. The cabin being the same width as the barge, a guard of 20 inches in width was put on each side. Outriggers of 6-inch square oak projected 5 feet on each end of the barges, on which oars were hung.

The boats, with the exception of one of the triangulation boats, were navigated by hand.

On September 25th I went to Saint Joseph, Mo., to inspect the steamer *Doris*, which had been secured as a tow and dispatch boat for the triangulation party. I found her in the water and that something had been done toward putting her machinery in order, but that she required yet several days' work of an engineer and fireman, as steam had not been raised on her since the season previous.

Not being able to procure an engineer for her at Saint Joseph, I sent to Saint Louis for one, directing him to go at once, take a fireman with him, and fit the *Doris* for service as soon as possible. He reached Saint Joseph on the 29th, and on the 5th of October had her in Kansas City.

Another 16 by 64 foot barge was procured from Major Livermore for carrying fuel for the *Doris*, as her carrying capacity is small, and it was learned that fuel could be obtained only at long intervals below Kansas City.

Before the arrival of the *Doris*, provisions, estimated to be sufficient for all the parties for ten weeks, were purchased and were on board the quarter-boats.

Everything was now ready for a start, but we were obliged to wait for the arrival of the outfit of dishes, cooking utensils, etc., from the United States steamer *Missouri*, a car load of which had been shipped from Bismarck, Dak., on the 28th of September.

October 8, the car containing outfit arrived, and a part of the contents was transferred to the quarter-boats that day. The remainder was gotten on board the next morning, and before noon the fleet started for Fort Leavenworth, the steamer *Melusina*, borrowed from Major Livermore for the purpose, taking the larger quarter-boat and fuel barge in tow, and the *Doris* the other two quarter-boats; arrived without accident at Fort Leavenworth on the 10th, at noon, where, after making further purchases to complete the outfit of the quarter-boats, all the boats, except one quarter-boat, were turned over to Assistant O. B. Wheeler, who was in charge of the triangulation, and who was then at work in the vicinity.

A portion of the property from the steamer *Missouri*, not needed for outfitting the quarter-boats, was, for want of storage-room on the boats, stored in the Government warehouse on the levee at Fort Leavenworth. A list of the property so stored is herewith transmitted.

The party for permanent bench-mark and level work consisted of one assistant in charge, one bench-mark party, two level parties, and one quarter-boat crew, made up as follows:

Bench-mark party—1 assistant engineer, 1 stadia rodman, 1 flagman, 5 laborers.
First level party—1 assistant engineer, 1 rodman, 1 axman, 1 shademan, 1 boatman.
Second level party—1 assistant engineer, 1 rodman, 1 ax and boat man, 1 shademan.
Boat's crew—1 mate, 3 boatmen, 1 watchman, 1 cook, 1 waiter and helper, 1 laundress.
Total number in party 25.

Work in the field on permanent bench-marks (hereafter in this report "P. B. M." or "B. M." when used stands for "permanent bench-marks") was commenced October 13, and was continued until December 2, when the quarter-boat was blown ashore and frozen fast, about half a mile below Berlin Landing.

On the night of the 3d, ice extended from the right bank, where the boat lay, half-way across the river, and during the following night the river closed entirely, and in the morning was solid as far up and down as could be seen.

This condition of things was immediately reported to you, and on the 6th I received orders to discharge the party and make preparations for hauling out on shore both my own and the boats of the triangulation party, which was to continue operations on land. One of the triangulation boats was then at Waverly and the other with the steamer *Doris* and fuel barge, near Laynesville, Mo., and about 30 miles below Berlin Landing.

The party, with the exception of a few men retained to assist in getting out the boats, was discharged on the 7th, and the next day Assistant Warren with five men was sent to Laynesville to commence operations, in the hope that, before the work there was finished, the ice might give way, the other boats be run down to the same place, and all taken out together.

The construction of temporary ways and two capstans was immediately begun, and arrangements made for blocks and lines to be sent from Kansas City. The work was pushed as rapidly as possible, but labored under the disadvantage of being 14 miles from an available railroad station and 5 miles from any place where supplies of any kind could be procured.

On the 22d, however, everything was completed and a pull made on one of the quarter-boats; but when it was about half-way up the incline, the lines passing over the angle of the bank at the top of the incline began to give way from the great friction to which they were subjected and the boat was shored up in that position until the matter could be remedied.

The ways were placed at an inclination of nearly 4 on 1 to the top of the bank, when they were laid level, and it was at this angle that the lines parted. To remedy this strong slings to go around the boat were made from the broken lines, and a pair of wire-rope slings which had been sent with the blocks and lines from Kansas City, and which had been used round the boat at first, were attached to the rope slings and led over the angle in place of the ropes used before. This worked admirably, and when the boat was again started it came up without further trouble.

In the mean time, while the ways were under construction, the ice had broken up and the other boats had been run down. that of the B. M. party arriving on the morning of the 23d. The next day all the boats were out of the water and in place on the ways except the *Doris*.

The ways were now changed to suit the length of the *Doris*, which is shorter than the other boats. A cradle was also made to place under her, as it was thought unsafe to attempt to pull her out with the bottom sliding on the ways. These preparations were completed on the evening of the 27th, and the following day the *Doris* was safely taken out and placed on the level.

All the boats were now leveled and blocked up, the machinery of the *Doris* put in order for winter, inventories of property on all the boats taken, and on the 30th the party was discharged, and the whole left in care of a watchman.

The permanent bench-mark lines crossed the valley of the river as nearly as practicable normal to its axis. The intention was to have the lines about 5 miles apart, but the distances were varied somewhat according to circumstances, as it was desirable to have open ground to facilitate the topographical work, and as narrow a river-crossing as possible for transferring levels.

The bench-marks were shipped from Saint Louis on the steamers *Alert* and *Etheridge*, and were distributed at convenient points between Glasgow and Fort Leavenworth. They were the same in kind as have been described in previous reports, namely: A stone 18 by 18 by 4 inches, set flat-wise and level, 3 feet in the ground, with a copper bolt projecting one-fourth inch from the upper surface, and a 4-inch iron pipe centered over that, the top standing a foot above the ground and covered with a cast-iron cap. The copper bolt is the real B. M. To use it, take off the cast-iron cap and let the rod down through the pipe on to the copper bolt.

Usually three of these "marks" were set in a line, but sometimes the situation was such that more than two seemed superfluous, in which case the third one was left out. Care was taken in locating them to place them as far as possible out of danger of disturbances, either from the caving of the river banks or other causes, and also where they could readily be found from a brief description.

The "marks" are designated by figures in the form of a common fraction, the numerator showing the number of the *line*, and the denominator the number of the "mark" in the line, commencing with the one on the right of the line looking down the river.

The numbering of the lines commences at the mouth of the river.

The topography on each side of the lines was sketched and all the lines connected with one of the triangulation stations. Most of the connections were made by running a stadia line from a P. B. M. to some △. A few were connected by angles alone.

It is to be regretted that the work on these connections could not have been thoroughly checked. Then, when the final reduction of the notes was made, each P. B. M. would

have been a definite starting point, both for azimuth and position, for any ordinary survey or other similar work. Now, while there is sufficient information to enable them to be located on the map with a precision closely approximating to accuracy, yet for lack of a check there can be no *certainty* as to either. Time, however, would not allow more work on the connections without delaying other portions.

As a rule the B. M. lines were straight from the first to the last "mark," but in a few instances, to avoid obstructions, an angle, which was carefully measured, would be made at one of the "marks." No angles were made except at a P. B. M.

Nineteen (19) lines were established and 49 P. B. M.'s set. Eight of the lines have only two "marks" each. The others have three each.

The first and upper line established (numbered 79) is just below and nearly parallel with the Chicago, Rock Island and Pacific Railroad bridge at Fort Leavenworth. The last one (numbered 61) is at Berlin Landing.

The length of river embraced within the upper and lower lines is 108.6 miles, making the average distance between lines by river 6.33 miles, while the average distance between lines, measuring along the axis of the valley, is 4.1 miles.

It so happened that most of the lines were located where the bluff came nearest the right bank of the river, so that a greater part of the lines have only one mark on the right bank and one or more on the left.

Elevations from the temporary bench-marks which were established in 1881, and which, with one or two exceptions, were all on the right bank, were transferred to all the P. B. M.'s. This was done by the two level parties in the following manner:

The first level (Assistant Warren, who was in immediate charge of level work) ran from the nearest temporary bench-mark, which was found intact, to, say, No. 1 on the P. B. M. line, and from there to a temporary bench-mark near the water's edge. The second level, in the mean time, commenced on the line on the opposite side of the river, starting from a temporary bench-mark, also near the water, and ran out to the farthest "mark" on the line. Each level then ran back over his line, working in the opposite direction, checking his own work. The river crossing was then made by both levels as follows: Each level, one on each side, took station about 50 feet above or below the temporary benches above mentioned and took two or three careful readings on the bench 50 feet distant as a back-sight, then generally a set of ten readings on the bench across the river. This done, the levels changed places and went through the same operation, except that the long sight was now used as a back-sight and the short one as a fore-sight. Unless there was some apparent reason for doing otherwise, the difference of elevation of the two benches was found from a mean of the four sets of readings.

The method of checking the levels by requiring the leveler to run over his own lines in the opposite direction was attended with very satisfactory results. The leveler being thus made responsible for all discrepancies, at once realized the necessity of keeping his instrument always in order and of constant care in its manipulation. The rodman kept full notes, and comparisons between the two were made in elevations only. At each back and fore sight two or three settings of the target were required, or until two or more readings checked or agreed within 0'.001. The turning pegs used on the first were not allowed to be used on the check-line, or, if used at all, were first driven down. The instruments were Buff & Berger levels, Nos. 391 and 392, with New York rods. The levels were at all times protected from sunshine and wind by shades designed for the purpose. Fore and back sights were equalized, none of them, except on river crossings, exceeding 300 feet in length.

The following is the method of procedure: The rodman being at a bench or peg, and having given three settings of the target that answer the requirements, sets the target at the mean reading and records the same. As he then approaches the instrument the leveler calls out the elevations of the bench or peg the rodman has just left, which the rodman halts to compare with his own record, at the same time presenting his rod to be read by the leveler, who examines it and calls out the last three figures of the reading, which the rodman also verifies by reference to his own book, and then passes on to the next peg. Here, after having given the three readings in the same manner as before, made his record, and set his target, he calculates the last height of instrument, the data for which he has already, while the instrument is coming up, and as the leveler approaches the peg calls this height of instrument, which the leveler verifies by reference to his note-book, and then checks the last rod reading as before by calling out the last three figures, and so on.

The following table shows the discrepancies between the first and check-lines of each level:

FIRST LEVEL.

From—	To—	Distance.	Discrepancy.	From—	To—	Distance.	Discrepancy.
		Feet.				*Feet.*	
272	$\frac{72}{1}$ and left bank of river.	3,780	0.012	221	[illegible] and river	1,000	0.003
[illegible]	[illegible]			[illegible]	[illegible]	5,760	0.004
[illegible]	[illegible]	500	0.005	214	Peg 5	1,800	0.001
268	[illegible] and river	4,900	0.008	Right bank of river.	Across to [illegible]	4,250	0.003
266	[illegible] and river	5,400	0.000				
261	[illegible] and river	6,800	0.002	210	[illegible] and river	1,000	0.000
255	River and [illegible]	8,200	0.000	207	[illegible] and river	7,000	0.001
248	[illegible]	17,000	0.002	202	River	1,200	0.001
[illegible]	River	700	0.004	River	[illegible]	980	0.002
240	[illegible]	7,300	0.003	196	[illegible] and river	1,060	0.001
234	[illegible] and river	1,360	0.006	C	[illegible]	8,000	0.001
X	[illegible]	4,260	0.002	190	[illegible] and river	3,800	0.000
33	[illegible] and river	2,100	0.002	Peg 15	[illegible]	6,000	0.006

SECOND LEVEL.

From—	To—	Distance.	Discrepancy.	From—	To—	Distance.	Discrepancy.
River	[illegible]	6,000	0.007	River	[illegible]	4,860	0.004
River	[illegible]	1,200	0.003	River	[illegible]	10,900	0.006
[illegible]	[illegible]	6,800	0.008	Peg 5	[illegible]	2,400	0.000
River	[illegible]	3,300	0.011	[illegible]	River	11,400	0.002
[illegible]	[illegible]	2,970	0.008	River	[illegible]	5,440	0.006
River	[illegible]	750	0.001	River	[illegible]	4,550	0.004
255	[illegible]	3,850	0.001	[illegible]	[illegible]	5,870	0.006
[illegible]	[illegible]	3,580	0.006	[illegible]	River	5,260	0.007
River	[illegible]	2,920	0.004	River	Peg C	10,650	0.007
[illegible]	[illegible]	3,260	0.008	River	[illegible]	6,480	0.001
243	$\frac{73}{1}$ and river	600	0.000	[illegible]	Peg 15	6,600	0.005
River	[illegible]	8,800	0.000	185	[illegible]	1,800	0.004
[illegible]	[illegible]	2,800	0.005	185	River	820	0.005
[illegible]	River	6,500	0.005	River	[illegible]	4,300	0.006
River	[illegible]	100	0.000	183	[illegible] and river	3,600	0.004
River	[illegible]	5,940	0.002	River	[illegible]	9,200	0.010
[illegible]	X	3,500	0,002	[illegible]	[illegible]	3,400	0.002

In ascertaining the elevation of a permanent bench-mark, all conditions being the same, a mean of all the observations leading to it has been taken. It frequently happened, however, that while running a "first line" (they were generally run in the morning) the temperature would be even, no wind, and the atmosphere clear and quiet, while the check would have to be made later in the day, with wind blowing and atmosphere boiling and perhaps other cause of uncertainty. In such cases—as evidently less weight should be given to the second than the first set of observations—a mean between the first set and a mean of the two sets was generally taken as correct. As errors (if any) on one bench-mark line are not transmitted to any other, it is believed that for practical purposes this method of reduction is as good as a more elaborate discussion.

In some instances, on the river crossings, when, for some reasons, there have been considerable discrepancies in one set of readings and very little in the other, the latter alone has been adopted.

The bench-mark work was in charge of Mr. J. D. McKown; the levels, of Mr. Albert Warren, assisted by Mr. John S. Bowen. To all these gentlemen thanks are due for faithful and efficient services, especially to Assistant Warren to whose watchful care and fidelity the good quality of the work in his charge is mainly attributable.

An inspection of the tables herewith presented indicates a greater degree of precision in the level work of the past season than has heretofore been attained. Upon a reduction of the notes of the level work done in 1884 at Glasgow and below, some large discrepancies (large compared with the past season's results) were found, and some results found to have been obtained by unauthorized methods.

I therefore recommend that when opportunity occurs, the levels of 1884 be re-run.

The cost of the quarters was as follows:

Lumber	$696.71
Hardware, paint, oil, etc	365.99
Labor, including salary of assistant in charge and, say, $50 expended on the hulls	1,052.95
Traveling expenses	31.50
Total	2,147.15

The two triangulations boats were alike and cost the same. The B. M. parties boat, on account of the addition of a guard and slightly larger cabin, is estimated to have cost about $75 more than either of the others.

The cost of subsistence stores purchased for the party up to December 1, was	$562.92
Estimated on hand December 1	114.25
Total cost to December 1	448.67

The actual time occupied on the permanent bench-mark work was from October 9, the date of leaving Kansas City for Fort Leavenworth, to December 1.

The cost of the work on the B. M. lines therefore, not including the cost of outfit and bench-marks, was:

Pay roll of party, October 9 to December 1	$1,997.69
Subsistence stores	448.67
Traveling expenses	62.50
Repair and transportation of instruments	22.80
Total	2,531.66

Miles of river covered	108.6
Cost per mile of river	$23.31
Number of P. B. M. lines	19
Cost per line	133.24
Number of rations consumed to December 1	1,325
Cost per ration ....cents	33.9
Cost per ration including wages of cook and helper ....cents	41.6

In calm weather the quarter-boats were easily handled by means of the oars at bow and stern, but in a wind, even one that seemed moderate, they were perfectly unmanageable, and then nothing could be done but let them go ashore and wait for calm.

Between October 16, when the first move down the river was made, and the 30th of November, when the boat was moved down to the site of the last B. M. line, more than seventy hours had been lost by the entire party from delays in moving the quarter-boat, on account of wind, equivalent to a loss on salaries and subsistence of the party of not less than $350 and of work accomplished of probably not less than three B. M. lines.

The additional expense of a tug to move quarters, whenever required, would have been the pay and subsistence of the crew of the tug and fuel for the same, less the pay and subsistence of two men that would not in that case be needed on the quarter-boat.

Pay of crew of tug, October 9 to December 1		$485.33
Subsistence		70.50
Fuel (fuel for November cost $40) say		69.33
		625.16
Deduct pay of two men	$104.00	
Subsistence	35.25	
		139.25
Total additional cost		485.91
Add		2,531.66
Total cost field work, including tug		3,017.57

Number B. M. lines with above, say 22. Cost per line, $137.07, or slightly more than cost of work actually done.

In addition to being able to move at any time, a tug would enable a great saving of time to be made in other ways, and consequently a still greater amount of work to be accomplished in a given time than is provided for in the above calculation.

It frequently happens that the B. M. party finishes work on a line early in the day, say at noon, while for some reason the level work on the same line can not be completed before the following day. In such a case the quarter-boat must be kept at the place over night for the accommodation of the level parties, and the B. M. party must remain idle the remainder of the day, for it would take all the afternoon, and perhaps more, to go to the site of a new line and back to quarters, while with a tug at hand the party could proceed at once to work on a new line, and the quarters be moved with or before them. The level parties could then easily come down the river to the boat at night and be taken back in the morning in a short time by the tug.

In view of these and other advantages, which are apparent, I feel assured that, even for the bench-mark work alone, some means of moving, other than by hand, would be found the more economical.

As previously stated, all the boats with the steamer *Doris* were left on the ways near Laynesville.

The quarter-boats and fuel-barge will require very litte repairs to fit them again for service. Some of the oars on the trangulation-boats are broken, and one of the boats has some holes stove in the cabin. That occupied by the B. M. party is in perfect repair.

If the boats are put into the water early in the spring probably no calking will be needed, unless it may be on the rakes. They were all blocked up level, and, if necessary, water can be pumped into the hulls to prevent them drying out. There is a good pump and sufficient hose on the *Doris*.

The machinery of the *Doris* is in good order, but on her hull, according to the engineer's report, there will be required one patch, 3 feet by 18 inches, on the starboard knuckle, 5 feet forward of boiler; one, 12 inches by 12 inches, under bottom forward of boiler, and one patch on port side, 10 inches by 12 inches, abreast the forward end of boiler. She also needs a small patch on the chimney. The chimney is pretty well rusted out, but will probably last another season.

The repairs on the *Doris* can all be made by the engineer and fireman.

Very respectfully, your obedient servant,

D. W. WELLMAN,
Assistant Engineer.

Lieut. THEO. A. BINGHAM,
Secretary Missouri River Commission.

Table showing the operations of each level and

P. B. M. line.	Origin of levels and its elevation above St. Louis City directrix for each P. B. M. line.		P. B. M. No. 1.				
	B. M.	Elevation.	First line.	Check line.	Mean.	Adopted.	Elevation above St. Louis City directrix.
79	272	358.137	18.477+	18.464+	18.470+	18.473+	376.610
78	268	330.214	44.781+	44.789+	44.785+	44.783+	374.997
77	266	349.358	36.780+	36.780+	36.780+	36.780+	386.138
76	261	343.397	2.143−	2.142−	2.143−	2.143−	341.254
75	255	337.633	8.753−	8.748−	8.750−	8.750−	328.883
74	248	364.200	31.011−	31.009−	31.010−	31.010−	333.190
73	243	341.735	9.033−	9.033−	9.033−	9.033−	332.702
72	240	328.682	7.645−	7.642−	7.643−	7.643−	321.039
71	234	327.441	8.362−	8.368−	8.365−	8.365−	319.076
70	(1878) "33"	319.062	7.364−	7.367−	7.365−	7.365−	311.697
69	221	310.720	7.566−	7.563−	7.565−	7.565−	303.155
68	214	298.735	7.612−	7.618−	7.612−	7.612−	291.123
67	210	303.876	5.312−	5.312−	5.312−	5.312−	298.564
66	207	289.731	3.605+	3.603+	3.604+	3.603+	293.334
65	202	287.275	7.263−	7.257−	7.260−	7.260−	280.015
64	196	285.336	4.617+	4.618+	4.617+	4.617+	289.953
63	190	306.579	6.195−	6.195−	6.195−	6.195	300.384
62	185	268.454	5.593	5.589−	5.591−	5.591−	262.863
61	183	273.197	4.317−	4.321−	4.319−	4.319−	268.878

P. B. M. line.	River crossings.						
	First level.			Second level.			Adopted.
	First line.	Second line.	Mean.	First line.	Second line.	Mean.	
79	0.670−	0.669−	0.670−	0.755−	0.596−	0.675−	0.670−
78	1.785−	1.819−	1.802−	1.893−	1.692−	1.793−	1.812−
77	1.510−	1.568−	1.539−	1.513−	1.581−	1.547−	1.512−
76	2.550+	2.402+	2.476+	2.359+	2.600+	2.479+	2.477+
75	0.256−	0.262−	0.259−	0.256−	0.269−	0.262−	0.256−
74	0.220−	0.159−	0.189−	0.215−	0.197−	0.206−	0.198−
73	0.804+	0.844+	0.824+	0.753+	0.835+	0.794+	0.824+
72	1.941−	1.940−	1.941−	2.032−	1.855−	1.943−	1.942−
71	5.668+	5.669+	5.668+	....	....	....	5.668+
70	1.741+	1.744+	1.742+	1.710+	1.707+	1.708+	1.725+
69	1.835−	1.847−	1.341−	1.314−	1.369−	1.341−	1.341−
68	6.398−	6.401−	6.400−	6.420−	6.479−	6.450−	6.400−
67	3.022−	3.017−	3.019−	3.035−	2.994−	3.015−	3.017−
66	1.119+	1.148+	1.133+	1.906+	1.168+	....	1.123+
65	3.924−	3.904−	3.914−	3.904−	3.924−	3.914−	3.914−
64	1.069−	1.329−	1.199−	1.320−	1.049−	1.185−	1.192−
63	0.820−	0.829−	0.825−	0.829−	0.820−	0.825−	0.825−
62	....	....	....	5.814−	5.840−	5.827−	5.837−
61	....	....	....	3.242+	3.196+	3.219+	3.219+

Elevations of permanent bench-marks, 1886–'87.

P. B. M. No. 2.					P. B. M. No. 3.				
First line.	Check line.	Mean.	Adopted.	Elevation above St. Louis City directrix.	First line.	Check line.	Mean.	Adopted.	Elevation above St. Louis City directrix.
3.475—	33.482—	33.478—	33.478—	343.133	4.469+	4.464+	4.467+	4.468+	347.600
8.377—	48.374—	48.376—	48.376—	346.621	2.786+	2.778+	2.782+	2.784+	549.405
6.329—	46.340—	46.334—	46.334—	339.804	0.973+	0.965+	0.969+	0.969+	340.778
5.251—	5.251—	5.251—	5.251—	336.003	....	....	....	....	....
0.710+	0.704+	0.707+	0.707+	319.590	33.306+	33.367+	33.366+	33.366+	362.956
7.165—	7.157—	7.161—	7.161—	326.029	10.135+	10.127+	10.131+	10.131+	336.160
9.470—	9.470—	9.470—	9.470—	323.232	2.136+	2.141+	2.138+	2.138+	325.370
3.128+	13.123+	13.125+	13.125+	334.164	....	....	....	....	....
8.031—	8.033—	8.032—	8.032—	311.044	10.296+	10.292+	10.294+	10.294+	321.338
4.024—	4.021—	4.022—	4.022—	307.675	....	....	....	....	....
5.346—	5.342—	5.344—	5.344—	297.811	8.742+	8.735+	8.739+	6.739+	306.550
5.187+	5.192+	5.190+	5.190+	296.313	....	....	....	....	....
4.785+	4.791+	4.788+	4.788+	303.352	....	....	....	....	....
9.670—	9.665—	9.667—	9.667—	283.667	0.893+	0.899+	0.896+	0.896+	284.563
7.771+	17.766+	17.769+	17.769+	297.784	....	....	....	....	....
5.314—	15.323—	15.318—	15.318—	274.635	....	....	....	....	....
7.890—	27.890—	27.890—	27.890—	272.494	4.940+	4.939+	4.940+	4.940+	277.434
1.037+	11.030+	11.034+	11.034+	273.897	....	....	....	....	....
2.100—	2.114—	2.107—	2.107—	266.771	2.201—	2.199—	2.200—	2.200—	264.571

Remarks.

First level, Albert Warren.	Second level, John S. Bowen.
Permanent bench-mark.	**River crossing.**
First level 272 to left bank and [illegible] to [illegible]. Air boiling.	Air clear.
First level 268 to left bank. Air boiling on check.	Air boiling.
First level 266 to river	Second results discarded on account air boiling.
First level 261 to river	Wind and sun, cloudy and hazy.
First level 255 across river to [illegible]. Second level 255 to [illegible] and [illegible].	Fair and quiet.
First level 248 to [illegible] and river. Fog, air boiling...	Dark and stormy.
First level on [illegible]	Dense smoke.
First level 240 to [illegible]	Clear and quiet.
First level 234 to left bank	Second level on line, clear and quiet.
First and second levels [illegible] to [illegible]. Windy. First level "33" to river. Windy.	Cold.
First level 221 to [illegible] and [illegible] to [illegible]	Changeable.
First level 214 to [illegible] and river to [illegible]	Very windy.
First level 210 to [illegible] and river	Smoky.
First level 207 to [illegible] and river	Error in reading rod, second level.
First level 202 to river and [illegible]. Windy. Second level [illegible] to river.	
First level 196 to [illegible] and river and part to [illegible]	Air boiling like furnace.
First level 190 to [illegible] and river and part to [illegible]	Smoky.
First level absent	
First level absent	Cold and windy.

[Missouri River Survey P. B. M. Field work

Table showing the operations of each level and elevation of permanent

No. of P. B. M. line.	Origin of levels and its elevation above Saint Louis City directrix for each P. B. M. line.		P. B. M. No. 1.			
	B. M.	Elevation.	First level.	Check level.	Mean.	Adopted
41	124	178.691	4.885+	4.895+	4.890+	4.890-
42	127	183.463	1.982—	1.980—	1.981—	1.981-
43	(1878) "61"	178.084	18.715+	18.692+	18.703+	18.70-
44	135	191.560	6.805—	6.788—	6.796—	6.796-
45	137	187.826	13.257+	13.226+	13.241+	13.241-
46	142	205.201	7.689—	7.690—	7.689—	7.689-
47	142	205.201	7.689—	7.690—	7.689—	7.689-
48	145	204.907	8.943+	8.937+	8.940+	8.940-

No. of P. B. M. line.	P. B. M. No. 2.					
	First level.	Check level.	Mean.	Adopted.	Elevation above St. Louis City directrix.	Distance between benches in feet.
41						
42	1.938+	1.927+	1.932+	1.932+	181.631	2,64
43	20.161+	20.173—	20.167—	20.167—	204.350	4,39
44	18.002+	17.989+	17.995+	17.995+	200.330	6,17
45	0.342+	0.364+	0.353	0.353+	186.605	3,99
46						
47	0.569—	0.624—	0.596—	0.596—	208.983	4,39
48						

[ovember and December, 1884.—Levels.]

ench-marks, also discrepancies of first level from check level.

P. B. M. No. 1.		P. B. M. No. 2.					
Elevation above Saint Louis City directrix.	Distance between benches, in feet.	First level.	Check level.	Mean.	Adopted.	Elevation above St. Louis City directrix.	Distance between benches, in feet.
183.591	4,279	5.082—	5.061—	5.072—	5.072—	178.509	5,200
181.482	800	1.752—	1.814—	1.783—	1.783—	179.699	4,689
196.787	4,633	12.618—	12.589—	12.604—	12.604—	184.183	6,000
184.764	7,500	2.448—	2.431—	2.439—	2.439—	182.325	8,800
201.067	2,000	14.813—	14.817—	14.815—	14.815—	186.252	5,200
197.512	4,746	0.728—	0.663—	0.695—	0.695—	196.817	7,687
197.512	4,748	7.047+	7.085+	7.066+	7.066+	204.578	5,222
213.847	6,523	11.551—	11.531—	11.541—	11.541—	202.306	4,367

Discrepancies of first level from check level between B. M's of each line.			Remarks. [First level, J. G. Jennings. Check level, H. Hutton.]
P. B. M. 1.	P. B. M. 2.	P. B. M. 3.	
+0.010—	—0.021+	....	No details of river crossings being given, no differences or means can be given in this table.
—0.002+	—0.062—	+0.011+	The + and — signs placed before the figures in the table of discrepancies show the elevations of the B. M. as above or below the previous bench.
+0.023+	—0.029+	+0.012—	The + or — signs placed after the figures in the table of discrepancies, show the difference of first level between the benches as more or less than the check level.
—0.017+	—0.017+	+0.013+	The distances given are the approximate distances between benches, river crossings distance not included.
+0.031+	—0.004—	+0.022—	
—0.001—	—0.065+	....	
—0.001—	+0.038—	—0.055—	
+0.006+	—0.020+	....	

The differences given above are compiled from the back and fore sights of Messrs. Jennings and Hutton.—ALBERT WARREN, *Assistant Engineer.*

APPENDIX A 2.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER.

OFFICE OF MISSOURI RIVER COMMISSION,
Saint Louis, Mo., July 13, 1887.

SIR: I have the honor to submit a report on the secondary triangulation of the Missouri River for the year ending June 30, 1887.

The season's field work is reported under date of June 1.

The office work, which was suspended on taking the field in September, was resumed late in January with one set of computers. During the latter part of March and April and May two sets were employed, and since then only one set. All computations are done in duplicate.

The work has been the reduction and tabulation from the field-note books of the angles read from Fort Leavenworth to the mouth of the river; the reduction of the base line at Beverly, Mo., near Fort Leavenworth; the reduction of azimuth observations at Fort Leavenworth and Glasgow; the adjustment by least squares of the triangulation; the geodetic computation of the triangulation, and the tabulation of results for the final report.

The same values for constants and methods of reduction as given in the last annual report were again used.

The Beverly base reduction is reported under date of May 23, 1887.

The results for azimuth at two stations are given in Tables II and III.

Table I gives a connected series of the best-conditioned triangles, and the results are in the order of observed and adjusted angles, length of lines, azimuth, latitude, and longitude.

The system was a series of quadrilaterals. There were, however, 13 figures more complicated than the quadrilateral, and 3 quadrilaterals in each of which one diagonal was not obtained. Also, the system was not strong in the vicinity of Washington, Mo., but there were lines of the U. S. Coast and Geodetic Survey on either side of the weak part, and these lines were used as bases. The triangulation was over 435 miles of river distance, through 142 stations, and 306 triangles. The number of angles entering into the adjustment was 595, and the corrections lie as follows:

Between 0″ and 1″	373
Between 1″ and 2″	182
Between 2″ and 3″	31
Between 3″ and 4″	9

The tabulated results depend on the following data for latitude, longitude, azimuth, and length of lines:

The latitude and longitude adopted is that of the Morrison Observatory, as found in "Publications of the Morrison Observatory, Glasgow, Mo., No. 1," 1885.

There were two series of observations for the latitude, giving identical results, namely: Latitude of meridian pier $= 39° 13' 45.'' 59 \pm '' .05$, and for longitude, five nights' observations and exchange of signals directly with the Naval Observatory at Washington. The personal equation was corrected for, and the result is:

Longitude of meridian pier $= 1^h 03^m 05.^s926$. The reduction from the meridian pier to the dome of the Morrison Observatory is zero in latitude, and $-0.^s019$ in longitude; and the longitude of Washington from Greenwich used was $=5^h 08^m 12.^s09$.

The bases and the discrepancies in lengths of lines as computed from the Glasgow base are as follows:

Bases.	Length of line.	Discrepancies.	
		Units seventh place of log's (computed value).	Ratio.
	Meters.		
Beverly (measured)	2,418.11	Too small by 305	1 in 15,000
Glasgow (measured)	2,414.94		
Cedar-Medlock (U. S. Coast Survey)	17,252.77	Too large by 199	1 in 22,000
Berger-Enoch Knob (U. S. Coast Survey)	13,696.33	Too small by 128	1 in 30,000
Enoch Knob-Dieckhaus (U. S. Coast Survey)	16,732.46	Too small by 286	1 in 15,000
Dieckhaus-Halleck (U. S. Coast Survey)	13,351.50	Too small by 197	1 in 22,000
Tavern Rock-Kessler (U. S. Coast Survey)	16,061.91	Too large by 108	1 in 40,000
Minoma-Sugar Loaf (U. S. Coast Survey)	23,612.52	Too large by 265	1 in 16,000

These bases were used as absolute and adjustment made for intermediate lines.

The azimuths and the discrepancies as computed from △ Glasgow — △ east base are as follows:

Azimuth lines.	Azimuth.	Discrepancies (computed value).
	° ′ ″	″
(1) △ Azimuth (Fort Leavenworth) to △ northeast base (observed).....	265 39 52.35	8.57 smaller.
(2) △ Glasgow to △ east base (observed)........	25 04 09.74	.00
(3) △ Cedar to △ Medlock (U. S. Coast Survey)........	103 25 42.—	7.54 smaller.

Azimuth (1) was used from Fort Leavenworth to Glasgow; (2) from Glasgow to Cedar City; (3) from Cedar City to Saint Louis. Azimuth (3) agreed to the nearest second with that of all other lines of the U. S. Coast and Geodetic Survey.

No adjustments for discrepancies in azimuth were made, since in mapping on a scale of 1 mile to 1 inch a discrepancy of 8.″57 would swing a point less than 0.01 of an inch in 200 miles.

The latitudes and longitudes, if computed from the values given for the engineer's observatory at Fort Leavenworth (see Chief of Engineer's Report for 1881, Part III, page 2838) would be, respectively, 1.″086 larger and 11.″068 smaller than those tabulated, and if computed from the values given by the U. S. Coast and Geodetic Survey for station "Cedar," would be, respectively, 6.″582 larger and 3.″772 smaller than tabulated. The Coast Survey values depend on "Clarke spheroid of 1866 and standard astronomical data of 1881."

The following assistant engineers have taken part in the computations: C. V. Mersereau, Bathurst Smith, T. C. Thomas, and J. J. Sanders; Mr. Mersereau having assisted through the entire work.

Very respectfully, your obedient servant,

C. B. WHEELER,
Assistant Engineer.

Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

APPENDIX A 3.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER, ON THE REDUCTION OF THE BEVERLY BASE.

OFFICE OF THE MISSOURI RIVER COMMISSION,
Saint Louis, Mo., May 23, 1887.

SIR: I have the honor to submit herewith the reduction and the results of the measurements of the Beverly base.

This base is located in Missouri, and about 2 miles east from Fort Leavenworth, Kans. It is alongside the Chicago and Rock Island Railroad, and about 3 feet to the west of the westerly rail, except △ southwest base, where it crosses the railroad track, and at △ northeast base, where the track curves away from the base.

The measurements were made on October 5, 1886, with the same steel tape, tape thermometer, adjuster, and method as are described in your last annual report. There were three wholly independent measurements made under the following conditions:

	Time, p. m.	Interval.	Temperature.	Range.	Remarks.
	h. m. *h. m.*	*h. m.*	° °	°	
First..........	3 16 to 5 05	1 49	84 to 76	8	Tape in hazy sunshine; thermometer in shade.
Second..........	7 18 to 8 39	1 21	67.9 to 62.9	5	Wholly by lamp-light.
Third..........	9 27 to 10 53	1 26	62 to 53.9	8.1	Do.

The first measurement was made while setting the zinc strips and while getting the force of sixteen persons in training. It was carefully made, however, and is considered a reliable measurement. The result falls between the second and third, and very near their mean.

The compared tape thermometer G was at the middle of the tape, and in first measurement always shaded from the sun, which was not shining brightly. The check thermometers R and F were at the rear and front ends of the tape respectively, and generally in the sunshine during first measurement.

The three results reduced to sea-level are:

	Feet.
First measurement =	7,933.5116
Second measurement =	7,933.5061
Third measurement =	7,933.5301

The direct mean of which is: Beverly base = 7,933.5159 feet, with a probable error, from the results themselves, of 1 in 1,640,000. (The extreme difference is = 0.024 feet = 0.3 inch.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Engineer.

First Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

The three measurements of the Beverly base are expressed by the following equations:

	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
(1)	26[illegible] × 299.079	+0.9612	+5.47	+1.0004		+0.2358	−0.0113	=7933.8027.
(2)	26[illegible] × 299.079	+0.1900	+6.8033		+0.4167	+0.3050	−0.0113	=7933.7972.
(3)	26[illegible] × 299.079	−0.2119	+6.8033		+0.8342	+0.3133	−0.0113	=7933.8212.

First term is the number of tapes multiplied by the length of tape at 62° Fahrenheit.
Second term is temperature correction.
Third term is distance between beginning of measurements and △ southwest base.
Fourth term is correction due to the fact that the second tape length of first measurement was from 0′ to 300′ graduation of tape.
Fifth term is distance set forward on zinc.
Sixth term is distance between mark on zinc No. 26½ and △ northeast base.
Seventh term is correction for inclination of tape.
The second member is the corrected independent result for each measurement.

	Feet.
The mean of the three measurements =	7933.8070
Correction to reduce to sea level =	—0.2911
Beverly base (reduced to sea level) =	7933.5119

The temperatures of the Beverly base.

Number of tape.	First measurement.				Second measurement.				Third measurement.			
	Oct. 5, 1886, p.m.	Thermometers.			Oct. 5, 1886, p.m.	Thermometers.			Oct. 5, 1886, p.m.	Thermometers.		
		G.	R.	F.		G.	R.	F.		G.	R.	F.
	h. m.	°	°	°	*h. m.*	°	°	°	*h. m.*	°	°	°
1	3 16	84.0	86.7	86.0	7 18	67.0	69.1	66.9	9 27	56.0	55.6	58.0
2	30	83.9	84.9	86.0	21	67.0	66.1	67.2	30	56.1	55.0	56.2
3	33	82.7	85.4	85.0	23	67.4	67.2	67.0	33	56.5	55.5	57.0
4	35	82.0	84.8	84.5	25	67.2	67.4	67.0	36	57.0	56.0	56.5
5	39	82.1	81.5	85.6	28	67.6	67.3	66.5	38	58.3	55.9	56.5
6	42	82.5	85.0	84.0	31	67.2	65.9	66.5	41	58.7	56.2	56.5
7	44	81.4	83.0	83.9	33	67.4	67.2	67.0	44	60.5	60.0	60.5
8	46	81.5	82.9	84.1	38	67.9	67.1	67.0	47	61.2	61.3	61.0
9	50	81.9	82.9	84.5	40	67.9	67.0	64.3	50	60.4	59.9	59.0
10	54	81.6	83.4	80.5	42	65.0	64.3	65.0	53	60.0	59.1	58.0
11	56	81.0	82.0	83.0	45	65.9	65.5	66.5	56	59.0	57.9	59.0
12	59	80.1	82.6	82.5	47	67.3	67.1	67.0	58	60.1	57.9	60.0
13	4 01½	80.1	82.0	82.5	50	67.6	67.0	67.0	10 00	60.8	59.2	60.2
14	28	79.9	81.2	83.2	52	67.8	67.1	67.0	03	61.5	60.1	61.0
15	31	80.0	80.9	81.5	55	67.3	67.0	66.5	06½	62.0	60.8	60.0
16	33	80.0	81.0	82.0	57	66.9	66.7	65.2	08½	61.4	60.1	59.9
17	36	79.9	81.0	82.0	8 00	66.4	66.4	65.9	11	61.2	60.0	59.9
18	38½	79.9	81.2	80.5	02	66.1	66.0	65.9	14	61.0	59.1	59.0
19	41	79.6	80.2	80.5	05	66.3	66.3	65.5	16	60.9	59.7	60.0
20	44	79.1	79.8	80.0	07	66.0	66.1	65.0	19	61.0	59.7	59.9
21	46½	77.8	79.8	77.8	10	66.3	65.3	65.1	22	60.2	59.4	60.0
22	48½	77.9	77.0	78.5	12	65.9	65.3	65.9	26	58.0	56.5	58.0
23	51	77.9	78.0	78.8	14	66.0	66.1	65.0	32	58.7	56.0	58.0
24	54	77.8	78.7	79.0	17	65.6	65.1	64.5	35	58.8	57.4	58.0
25	56	77.5	78.3	78.5	20	66.0	65.3	64.9	39	58.9	57.0	59.9
26	5 00	77.0	78.6	78.0	34	64.1	65.0	62.5	45	57.7	58.3	56.0
26½	05	76.0	76.4	76.5	39	62.9	63.3	61.9	53	53.9	54.1	52.2
Mean observed temperature, first 26 tapes	80°.346				66°.658				59°.458			
Correction	− 0.87				− 1.16				− 1.175			
Mean corrected temperature, first 26 tapes	79°.476				65.498				58.283			
Observed temperature, last ½ tape	76°.00				62.9				53.9			
Correction	− 0.99				− 1.2				− 1.12			
Corrected temperature, last ½ tape	75°.01				61.7				52.78			

First measurement:

Feet.	*Feet.*
26×0.002092×(79°.476—62°)=	+0.95055
[illegible]×0.002092×(75°.01 −62°)=	+0.01365
Temp. corrected for base...=	+0.9642

Second measurement:

Feet.	*Feet.*
26×0.002092×(65°.498—62°)=	+0.19026
[illegible]×0.002092×(61°.7 —62°)=	−0.00031
=	+0.18995

Third measurement:

Feet.	*Feet.*
26×0.002092+(58°.283—62°)=	−0.20217
[illegible]×0.002092+(52°.78 —62°)=	−0.00968
=	−0.21185

NOTE.—Thermometer G (tape thermometer) is a compared thermometer belonging to the Mississippi River Commission. Thermometers R and F are two uncompared thermometers belonging to the Missouri River Commission. G was carried about the middle of the tape; the other two being carried at the rear and front ends, respectively. In computing the temperature correction the readings of G only are used, the readings of the others being used as a check.

Beverly base—Correction for inclination (i) of tape.

Number of stake.	Elevation.	Difference of elevation=p.	i.	Correction.	Number of stake.	Elevation.	Difference of elevation=p.	i.	Correction.
	Feet.	Feet.	′ ″	Feet.		Feet.	Feet.	′ ″	Feet.
△ S. W. base	0.352				16	3.093	.152	1 45	0.0000
1	0.000	0.352	4 03	0.0002	17	2.867	.226	2 35	.0001
2	0.602	.602	6 55	.0006	18	2.258	.609	7 00	.0006
3	0.257	.345	3 58	.0002	19	2.642	.384	4 25	.0002
4	0.080	.177	2 02	.0001	20	2.448	.194	2 14	.0001
5	1.038	.958	11 01	.0015	21	2.790	.342	3 56	.0002
6	0.785	.253	2 54	.0001	22	2.891	.101	1 10	.0000
7	0.614	.171	1 58	.0001	23	3.235	.344	3 57	.0002
8	0.730	.116	1 20	.0000	24	3.983	.748	8 36	.0009
9	1.460	.730	8 23	.0009	25	4.743	.760	8 44	.0010
10	2.495	1.035	11 54	.0018	26	4.776	.033	0 23	.0000
11	2.793	0.298	3 26	.0002	26½	5.329	.553	12 40	.0010
12	2.258	.535	6 09	.0005					
13	2.854	.596	6 51	.0006	Total correction for inclination of tape				
14	3.157	.303	3 29	.0001					
15	2.941	.216	2 29	.0001					0.0113

	Feet.
Mean elevation of base above stake No. 1	2.35
Mean elevation of base below stake No. 13	0.5
Elevation of stake No. 13 above water-surface of Missouri River on October 9, 1886	19.6
Mean elevation of base above water-surface of Missouri River on October 9, 1886	19.1
Elevation of water at Fort Leavenworth bridge above Saint Louis directrix October 9, 1886	335.2
Elevation of water-surface at stake No. 13 above water surface at Fort Leavenworth bridge October 9, 188	+1.8
Elevation of Saint Louis directrix above Gulf	412.7
Elevation of base-line above sea	768.8
Reduction to sea-level	—0.2911

Beverly base-line—Measurement of differences at end of each tape.

[The second measurement is taken as the standard and the difference recorded as corrected to the first and third measurements.]

No. of zinc.	Second measurement—First measurement.			Second measurement—Third measurement.		
	Reading on zinc.	Correction.	Reduced.	Reading on zinc.	Correction.	Reduced.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
0	+16.00*			+ 0.00		+0.00
1	†					
2	+ 2.94‡		+2.94	+ 0.78		+0.78
3	+ 2.56		+2.56	+ 1.02		+1.02
4	+ 2.16		+2.16	+ 1.28		+1.28
5	+ 1.80		+1.80	+ 1.50		+1.50
6	+ 1.38		+1.38	+ 1.73		+1.73
7	+ 1.05		+1.05	+ 1.87		+1.87
8	+ 0.69		+0.69	+ 2.03		+2.03
9	+ 0.31		+0.31	+ 2.19		+2.19
10	— 0.18		—0.18	+ 2.23		+2.23
11	— 0.50		—0.50	+ 2.48		+2.48
12	— 0.81		—0.81	+ 2.69		+2.69
13	— 1.13		—1.13	+ 2.85		+2.85
14	— 1.45		—1.45	+ 2.95		+2.95
15	— 1.78		—1.78	+ 3.12		+3.12
16	— 2.10		—2.10	+ 3.27		+3.27
17	— 2.39		—2.39	+ 3.45		+3.45
18	— 2.73		—2.73	+ 3.65		+3.65
19	— 3.04		—3.04	+ 3.79		+3.79
20	— 3.37		—3.37	+ 3.93		+3.93
21	— 3.68		—3.68	+ 4.10		+4.10
22	— 3.91		—3.91	+ 4.37		+4.37
23	— 4.16		—4.16	— 5.46	+10.01‖	+4.55
24	— 4.48		—4.48	— 5.36		+4.65
25	— 4.83		—4.83	— 5.16		+4.85
26	— 0.14	—5.00§	—5.14	+ 0.00	— 5.01	+5.01
26½	— 0.23		—5.23	+ 0.10		+5.11

* Set forward 16 inches on zinc 0, second and third measurements.
† Zinc on stake 1 was on railroad track and was run over between measurements.
‡ The second tape length of the first measurement was from 0′ to 300′ graduation on tape.
§ Set forward 5.00 inches on zinc No. 25, second measurement.
‖ Set forward 10.01 inches on zinc No. 22, third measurement.

APPENDIX A4.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER, DURING SEASON OF 1886, ON FIELD WORK BY PARTY ON SECONDARY TRIANGULATION.

OFFICE OF MISSOURI RIVER COMMISSION,
Saint Louis, Mo., June 1, 1887.

SIR: I have the honor to submit herewith a report on the field work done by the party on secondary triangulation during the season of 1886.

The appropriation was not available until late in the season, and then the work assigned was to begin at Fort Leavenworth, Kans., and to close at Glasgow, Mo., on the work of 1884-'85. Later it was decided to carry the unfinished work of 1884-'85 from △ Tavern Rock to the mouth of the Missouri River, and to close the work on a line of the U. S. Coast and Geodetic Survey, near Saint Louis.

On September 30, Assistant Engineers C. V. Mersereau and Bathurst Smith, as observers, arrived with myself at Fort Leavenworth, and a base-line, stations for lines coming off the base, and a station for azimuth observations were located. On the morning of October 1, Mr. J. J. Sanders reported as assistant engineer to have charge of a station-building party. Three rodmen reported, and seven men were hired. Preparations for the measurements of the base-line and the chopping out of lines from the base stations were done and the base measured on October 5. Three measurements of the base were made between 3 p. m. and 11 p. m.

The azimuth observations were made on the nights of October 7, 9, and 10. Three sets of observations on δ *Ursæ Minoris*, near western elongation, and one on α *Ursæ Minoris*, near eastern elongation, and time-star observations on each night for the approximate error of the chronometer were made.

Station building, the clearing of lines, and angle reading were continued in the vicinity of Fort Leavenworth until the 11th, when the two quarter-boats, the steam-launch *Doris*, and a coal-barge were in readiness for the use of the triangulation party.

The party was then organized to consist of 32 persons, distributed as follows: The 17 on the forward quarter-boat were, the crew of 4 for the *Doris;* the mate, watchman, cook, and second cook for the quarter-boat; the 6 for the station-building party, and the 3 for the reconnoitering party. The 15 on the observer's quarter-boat were, the 6 for each observing party, and the mate, cook, and second cook. The progress made with the boats during the fine weather of October was 5 miles per day. On December 2 the river blocked with ice, and the work was then carried on from the vicinity of Malta Bend to Glasgow from wagons, as was done in the winter of 1884-'85 (see last annual report).

The connection at Glasgow with the former work there was made on January 2, and the party then came to the vicinity of △ Tavern Rock. On account of the inclemency of the weather the field force was reduced on January 17 to one observing and one station-building party, and they completed the work to join on lines of the Mississippi River Survey and of the U. S. Coast and Geodetic Survey in the vicinity of Saint Louis, on March 19.

The summary of the work is as follows: 1 base line, three times measured; 3 nights' azimuth work on four stars near elongation; 23 stars for approximate time determination; 80 stations occupied; 68 new stations located, marked, and necessary lines cut; 326 angles of triangulation, each of 16 pointings or of eight combined positive and negative results; numerous readings to connect the triangulation with permanent buildings, section corners, etc.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Engineer.

First Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

APPENDIX A 5.

REPORT OF MR. JAMES A. SEDDON, ASSISTANT ENGINEER.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., July 14, 1887.

SIR: I have the honor to make the following report of the physical data department for the fiscal year ending June 30, 1887.

COMPILATION OF THE DATA.

Gauges.—The gauge readings were plotted up as received for check on the observers and the current gauge histories compiled.

Cross-sections and slope.—The 276 Omaha cross-sections, incomplete in the last annual report, were completed, viz: Areas measured, elements calculated, and tabulations made. Forty additional cross-sections at Omaha were compiled complete, with tabulation and reference map. This completes the compilation of cross-section data at Omaha. The slope, 61 miles in all, was also plotted and tabulated, completing the compilation of slope data at Omaha.

Discharge.—The 29 Omaha discharge observations of 1882, incomplete in last annual report, have been completed, with tabulation and reference map; and 40 additional discharge observations at Omaha have been compiled complete, with tabulations and reference maps, as follows: 21 observations of 1878, 14 of 1879, and 5 of 1880. In several of these Omaha observations there are two or more independent determinations of the same discharge, in which case the mean was taken in the published tabulation.

Thirty-three discharge observations at Nebraska City, taken in 1882, were revised, datum elements computed, and tabulation and reference map made.

Fourteen discharge observations of 1878 and twenty-six of 1879 at Sioux City were revised, widths, mean depths, and datum elements computed and tabulation and reference map made.

In the Nebraska City and Sioux City discharge data some additional work may be desirable in order to make the final filed records as uniform as possible. With this exception the above completes the final compilation of all the discharge observations that have been taken on the Missouri River. The tabulations of discharge data have also been all prepared for publication, with notes to accompany them.

Miscellaneous.—A series of sediment observations taken at Saint Charles, Mo., in 1879 were revised, recomputed, and tabulated. A tabulation was also prepared for publication, with plates of the variations and notes giving methods followed and discussion of the observations.

It will be seen by reference to the table in the last annual report that the compilation of the data is about completed, with the exception of such cross-section and slope data as were taken at Brownville, Plattsmouth, and Sioux City, at which points comparatively few sections were taken. The indexing and filing of all the data is also still to be done.

STUDY OF THE DATA.

In the study of gauge relations and discharge-gauge variations, as carried on under the theories presented in the last annual report, it was suggested by the data that increments to the discharge, reaching a river from tributaries, might have very different effects on gauge-heights at points below from increments of the same value reaching those points in the regular rises of the whole river. As this was a question vitally affecting the determinations of discharge from gauge-readings, investigation in the main has been directed towards it. The investigation has involved all data bearing on the subject, viz: gauge relations, discharge-gauge variations, and rise and fall of tributaries on the Missouri and Upper and Lower Mississippi Rivers. It has been carried far enough to make it apparent that at some localities this abnormal tributary effect is very marked, but whether it is universal, and to what degree it may be valued, are still questions. This investigation is still in progress.

Very respectfully, your obedient servant,

JAMES A. SEDDON,
Assistant Engineer.

First Lieut. THEO. A. BINGHAM,
Corps of Engineers,
Secretary Missouri River Commission.

GENERAL NOTES TO THE DISCHARGE OBSERVATIONS ON THE MISSOURI RIVER.

In the main all the discharges taken on the Missouri River were measured by the use of double floats, the lower float being run at approximate mid-depth, and from the observed data the discharge was calculated by the "graphic method," as follows:

The cross-section, normal velocity curve, and elements of discharge were plotted from the water-line of the middle section, the elements of discharge being the product of velocity and depth at every point where the velocity was observed and at pronounced points of flexure in the cross-section. These elements of discharge, plotted as ordinates from the water-line, give the discharge curve, whose area, measured with the planimeter, gives the cubic discharge through that cross-section.

In the few cases where discharges were observed or computed by methods differing from the above the method will be stated in the special notes to those discharges.

For all the Missouri River discharges the gauge-readings above Saint Louis Directrix given are the elevations of water-surface at the regular U. S. Engineer's gauge in that vicinity, the only elevations at the location of the discharge site given being those with the Kaw River discharges. All these elevations above the Saint Louis Directrix, as well as those of datum planes in the special notes, are elevations of the 1885 reductions, and correspond with those of the printed gauge records. The further correction of +0′.300, should be applied for the true elevation above the Directrix as at present determined.

SPECIAL NOTES TO THE SERIES OF DISCHARGE OBSERVATIONS.

DISCHARGE OBSERVATIONS AT SAINT CHARLES, MO.

Series 1878–'79.—These discharges were taken on various sections from about 600 to 1,000 feet above the Saint Charles Bridge, as follows:

Observations Nos. 1 to 8 on discharge section No. 1, about 600 feet above bridge, following to observation No. 72 on discharge section No. 2, 200 feet above No. 1, following to observation No. 91 on section No. 3, 225 feet above No. 2, after which section No. 2 was used to the end of the series.

The datum plane for all the sections was assumed as stage 13′.70 above the Saint Louis Directrix on the Saint Charles U. S. Engineer bridge gauge.

DISCHARGE OBSERVATIONS AT KANSAS CITY, MO.

Series 1883.—These discharge observations were taken at two sections below the Kansas City Bridge as follows: Observations Nos. 1 to 16 on discharge section No. 1, 6,200 feet below the bridge, following to the end of the series on discharge section No. 2, 3,100 feet below bridge.

The datum plane for discharge section No. 1 was assumed as stage 321′.00, and for section No. 2 as stage 314′.00 above the Saint Louis Directrix on the Kansas City U. S. Engineer bridge gauge.

KAW RIVER DISCHARGE.

Series 1883.—In connection with the 1883 Missouri River discharge observations at Kansas City a series of discharge observations were taken on the Kaw River, 8,400 feet above its mouth.

The datum plane was assumed as stage 318′.27 above the Saint Louis Directrix on the local gauge read at the site of these discharge observations during that time.

In addition to the column of gauge-readings above Saint Louis Directrix on the local gauge the Missouri River gauge-readings at Kansas City Bridge are also given with these discharges, as the height of the water-surface in the Kaw River at the observation site is largely dependent on the stage of the Missouri.

DISCHARGE OBSERVATIONS AT ATCHISON, KANS.

Series 1882.—These discharge observations were taken on a section located 1,700 feet below the Atchison Bridge. The datum plane was assumed as stage 368′.80 above the St. Louis Directrix on the Atchison U. S. Engineer gauge.

DISCHARGE OBSERVATIONS AT SAINT JOSEPH, MO.

Series 1878.—These discharge observations were taken at a location 2.2 miles above the Saint Joseph Bridge. The datum plane was assumed as stage 386′.15 above the Saint Louis Directrix on the Saint Joseph U. S. Engineer gauge.

It is not understood why there is such a variation in width, unless different sections were sounded. This is indeterminate, as the original notes were lost in the burning of the Saint Joseph office.

DISCHARGE OBSERVATIONS AT NEBRASKA CITY, NEBR.

Series 1882.—These discharge observations were taken 8.5 miles above Nebraska City, at the mouth of Squaw Creek. The datum plane was assumed as stage 505′.24 above the Saint Louis Directrix on the Nebraska City U. S. Engineer gauge.

In these observations the middle section was specially sounded only a few times during the series. A sounding was taken on the upper, middle, and lower section after each float, and a discharge section made up as the mean of the three sections so determined.

In this case, as the observed data was generally insufficient to determine accurately the middle section, and as the original calculations had been made with this mean section, it was thought unnecessary to recompute the discharges. The datum width was taken as the width of the middle section at datum elevation from a special sounding of this section. From the above there results the slight incongruity between the datum and water widths of the tabulation. In all other respects the series conform to the standard method.

DISCHARGE OBSERVATIONS AT OMAHA, NEBR.

Series 1878.—These discharge observations were taken on various sections approximately 2 miles above the Union Pacific Bridge. The exact location is not known, nor the relative positions of the different sections, the change of section being simply given in the records, as noted in the remarks accompanying the tabulation. The datum plane for all the sections was assumed as stage 553′.00 above the Saint Louis Directrix on the Omaha U. S. Engineer gauge.

In these observations the upper and lower sections were sounded, and in the calculations a discharge section was made up as the mean of the two. In other respects they conform to the standard method.

Series 1879.—These discharge observations were taken at two different locations. First, observations Nos. 1 to 4 were taken on a section 2,000 feet above the Union Pacific Bridge. Second, observations Nos. 5 to 8 were taken in two channels at Willow Island, 6.7 miles above the bridge.

The datum plane for the first was assumed as stage 553′.00, and for the second as stage 551′.27 above the Saint Louis directrix on the Omaha U. S. engineer bridge-gauge.

Series 1880.—These discharge observations were taken at two different locations. First, observations 1, 2, 4, 5 were taken on section at Florence, Nebr., 10.8 miles above the Union Pacific Bridge. Second, observation No. 3 was taken at Willow Island, 6.7 miles above the bridge. The datum plane for both locations was assumed as stage 554′.86 above the Saint Louis directrix on the Omaha U. S. engineer bridge-gauge.

In the first or Florence observations the velocity was measured with rod floats. In other respects the series conform to the standard method.

Series 1882.—These discharge observations were taken on various sections near Florence, Nebr., 10.8 miles above the Union Pacific Bridge, as follows: Observation No. 1 was taken on discharge section No. 1; observations Nos. 2, 25, 26, and 27 were taken on discharge section No. 2, 250 feet below No. 1; all the other observations were taken on section No. 3, 1,000 feet below section No. 2. The datum plane for all the sections was assumed as stage 557′.00 above the St. Louis directrix on the Omaha U. S. engineer bridge-gauge.

In this series the velocities for observations Nos. 1 to 9 were measured by floats run at surface, mid-depth, and bottom, and the mean of the three was used in calculation for the mean velocity at that point of the section. In other respects the series conforms to the standard method.

DISCHARGE OBSERVATIONS AT SIOUX CITY, IOWA.

All the discharge observations taken at Sioux City were originally calculated by the method of partial areas, the velocity on the path of floats being used instead of the normal velocity. These were not recomputed, since the records in this office of the observations were incomplete. However, other observations that were originally calculated by the same method, and that were recomputed in this office by the graphic method, were found to show in the main very insignificant differences between the results of the two computations.

Series 1878.—These discharge observations were taken on a section at Sioux City, 700 feet below the mouth of Perry Creek. The datum plane was assumed as stage 669′.94 above the Saint Louis directrix on the Sioux City U. S. engineer gauge.

In observations Nos. 1, 2, 3, 4, 6 the middle section was not sounded, the mean of the upper and lower sections being used in the calculations (as in the case of Nebraska City, a slight incongruity between the water and datum widths also follows here from this use of the mean section). In observations Nos. 1, 2, 8 the velocity was measured with double floats; in all the other observations of this series the velocity was measured with rod floats.

Series 1879.—These discharge observations were taken at the same section as the series of 1878, viz: 700 feet below the mouth of Perry Creek. The datum plane was assumed as stage 677′.41 above the Saint Louis directrix on the Sioux City U. S. engineer gauge.

In this series, with the exception of Nos. 1, 15, 16, 26, the data not being given in the riginal calculations for determining the water widths and datum areas, the values of hese were interpolated, giving also the mean depths as partly depending on interpola-ion as indicated in the tabulation.

Missouri River—Discharge observations at Saint Charles, Mo.

No.	Date.	Gauge readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
								Area.	Width.	Mean depth.
	1878.	*Feet.*	*Cu. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*
1	Dec. 12	7.17	35,660	10,900	3.27	1,346	8.10	20,148	1,500	13.42
	1879.									
2	Feb. 6	7.94	40,000	11,075	3.61	1,386	7.99	19,308	1,500	12.87
3	Feb. 8	7.50	36,370	10,295	3.53	1,357	7.76	19,208	1,500	12.81
4	Feb. 13	8.36	45,990	11,390	4.04	1,396	8.16	19,346	1,500	12.90
5	Feb. 19	6.17	25,700	8,580	3.00	1,335	6.43	19,327	1,500	12.88
6	Feb. 20	6.03	24,060	8,610	2.79	1,316	6.54	19,536	1,500	13.02
7	Feb. 24	6.73	29,050	9,425	3.08	1,341	7.03	19,424	1,500	12.95
8	Feb. 25	7.01	32,240	10,180	3.16	1,347	7.56	19,774	1,500	13.18
*9	Mar. 1	6.54	29,100	9,355	3.11	1,271	7.36	19,920	1,600	12.45
10	Mar. 5	6.07	25,520	8,895	2.87	1,261	7.05	19,960	1,600	12.49
11	Mar. 7	6.23	27,280	9,135	2.99	1,267	7.21	20,060	1,600	12.54
12	Mar. 8	6.43	28,340	9,235	30.7	1,274	7.25	19,980	1,600	12.49
13	Mar. 12	8.03	40,220	11,620	3.46	1,316	8.83	20,180	1,600	12.61
14	Mar. 13	7.94	38,780	11,460	3.38	1,313	8.73	20,020	1,600	12.51
15	Mar. 15	9.02	47,230	12,540	3.77	1,384	9.06	19,800	1,600	12.60
16	Mar. 17	9.40	52,320	13,840	3.78	1,413	9.79	20,470	1,600	12.79
17	Mar. 18	9.40	52,950	13,645	3.88	1,413	9.66	20,810	1,600	12.69
18	Mar. 19	9.67	60,900	14,510	4.20	1,428	10.16	20,720	1,600	12.95
19	Mar. 20	9.83	58,240	14,495	4.02	1,448	10.01	20,460	1,600	12.79
20	Mar. 21	9.78	55,580	14,120	3.94	1,452	9.72	20,040	1,600	12.52
21	Mar. 24	8.83	46,810	13,015	3.60	1,385	9.40	20,400	1,600	12.75
22	Mar. 25	8.60	44,780	12,655	3.54	1,368	9.25	20,380	1,600	12.74
23	Mar. 27	8.08	39,950	11,905	3.36	1,316	9.04	20,280	1,600	12.67
24	Mar. 31	7.64	35,220	11,350	3.10	1,303	8.71	20,390	1,600	12.74
25	Apr. 4	11.67	74,740	16,470	4.54	1,584	10.40	19,960	1,600	12.47
26	Apr. 5	11.47	74,690	17,550	4.25	1,570	11.18	21,210	1,600	13.26
27	Apr. 11	17.57	190,270	27,940	6.81	1,900	14.70	21,650	1,596	13.57
28	Apr. 13	17.97	204,820	29,280	7.00	1,990	15.41	21,880	1,650	13.26
29	Apr. 15	18.14	178,870	27,820	6.43	1,876	14.83	20,050	1,612	12.44
30	Apr. 18	15.58	132,510	26,233	5.05	1,646	15.94	23,400	1,555	15.05
31	Apr. 19	14.77	118,150	24,735	4.78	1,648	15.01	23,110	1,625	14.22
32	Apr. 22	13.23	87,920	20,715	4.24	1,531	13.53	21,530	1,550	13.89
33	Apr. 23	12.84	84,350	19,580	4.31	1,526	12.83	20,930	1,550	13.50
34	Apr. 25	12.24	75,000	18,615	4.03	1,487	12.52	20,950	1,550	13.52
35	Apr. 26	12.11	75,140	18,225	4.12	1,486	12.26	20,550	1,550	13.26
36	Apr. 29	11.72	71,550	18,194	3.93	1,472	12.36	21,240	1,550	13.70
37	Apr. 30	11.62	70,490	17,740	3.97	1,470	12.07	21,060	1,550	13.59
38	May 1	11.57	66,170	17,030	3.89	1,467	11.61	20,260	1,550	13.07
39	May 2	11.52	66,220	17,280	3.83	1,459	12.09	20,600	1,550	13.29
40	May 5	11.32	61,700	16,205	3.79	1,412	11.52	19,930	1,550	12.86
41	May 6	11.32	62,220	16,145	3.85	1,412	11.44	19,750	1,550	12.74
42	May 7	11.53	62,580	16,285	3.84	1,470	11.08	19,780	1,550	12.76
43	May 8	12.24	77,570	18,795	4.13	1,495	12.57	21,080	1,550	13.60
44	May 9	12.42	79,690	19,325	4.12	1,494	12.94	21,070	1,550	13.59
45	May 13	12.57	85,110	18,854	4.51	1,528	12.34	21,700	1,550	14.00
46	May 14	12.46	87,600	19,100	4.58	1,527	12.51	20,960	1,550	13.52
47	May 15	12.51	79,770	18,990	4.20	1,528	12.43	20,610	1,550	13.30
48	May 16	12.65	85,580	19,610	4.36	1,531	12.52	21,320	1,550	13.75
49	May 17	12.56	86,810	19,965	4.35	1,528	13.07	21,790	1,550	14.06
50	May 19	12.41	84,600	19,235	4.39	1,495	12.88	21,160	1,550	13.65
51	May 20	12.26	72,650	16,975	4.28	1,491	11.39	19,150	1,550	12.35
52	May 21	12.34	72,060	16,535	4.36	1,492	11.08	18,600	1,550	12.00
53	May 22	12.50	75,010	17,124	4.38	1,496	11.45	18,930	1,550	12.21
54	May 23	12.61	78,820	17,530	4.49	1,525	11.49	19,150	1,550	12.35
55	May 26	12.26	74,220	16,300	4.55	1,495	10.90	18,520	1,550	11.95
56	May 27	12.32	72,790	16,550	4.40	1,491	10.60	18,710	1,550	12.07
57	May 28	12.50	76,960	17,545	4.39	1,498	11.72	19,560	1,550	12.62
58	May 30	12.97	78,870	17,610	4.48	1,533	11,49	18,780	1,550	12.12
59	May 31	13.20	83,420	17,925	4.65	1,535	11,69	18,710	1,550	12.07
60	June 2	13.17	84,380	18,358	4.60	1,536	11.95	19,030	1,550	12.28
61	June 4	14.88	111,250	21,106	5.27	1,652	12.78	19,280	1,535	12.56
62	June 5	14.87	108,570	20,806	5.22	1,652	12.60	18,910	1,535	12.32
63	June 6	15.16	117,820	21,644	5.42	1,657	13.07	19,200	1,570	12.23
64	June 7	15.72	121,990	22,216	5.49	1,665	13.34	18,720	1,540	12.16
65	June 9	16.23	127,950	23,215	5.51	1,672	13.89	18,850	1,575	11.97
66	June 10	16.00	125,110	22,516	5.56	1,667	13.51	18,610	1,635	11.38

*Gauging sections changed.

Missouri River—Discharge observations at Saint Charles, Mo.—Continued.

No.	Date.	Gauge-readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
								Area.	Width.	Mean depth.
	1879.	Feet.	Cu. feet.	Sq. feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Feet.
67	June 12	16.00	123,660	23,128	5.35	1,670	13.85	19,300	1,630	11.63
68	June 13	16.46	128,110	23,750	5.39	1,681	14.13	18,880	1,660	11.37
*69	June 14	16.28	133,250	24,130	5.52	1,679	14.37	19,730	1,640	12.03
70	June 16	17.30	142,410	25,553	5.57	1,753	14.57	19,390	1,675	11.58
71	June 17	17.07	136,750	25,124	5.44	1,743	14.41	19,180	1,680	11.42
72	June 18	17.63	153,770	26,198	5.87	1,765	14.85	19,390	1,680	11.54
*73	June 23	19.54	191,520	30,290	6.32	1,957	16.92	19,880	1,630	12.19
74	June 24	20.26	211,450	31,714	6.67	1,982	16.00	20,430	1,640	12.46
75	June 25	19.30	179,640	29,752	6.01	1,960	15.18	20,210	1,660	12.17
76	June 26	19.66	194,360	30,893	6.29	1,948	15.86	20,340	1,670	12.18
77	June 30	23.06	290,270	35,460	7.90	2,041	17.37	18,020	1,680	10.73
78	July 1	22.94	284,890	39,248	7.26	2,045	19.20	21,500	1,695	12.68
79	July 3	23.33	290,800	41,060	7.08	2,043	20.10	22,630	1,730	13.08
80	July 5	22.38	257,170	38,385	6.70	2,031	18.87	21,650	1,720	12.59
81	July 7	21.53	247,550	36,366	6.81	1,998	18.20	21,830	1,745	12.51
82	July 8	21.38	218,260	35,840	6.09	1,971	18.18	21,810	1,750	12.46
83	July 9	21.11	222,900	35,930	6.20	1,969	18.25	21,950	1,760	12.47
84	July 10	20.69	220,400	36,010	6.12	1,969	18.29	23,130	1,745	13.25
85	July 11	20.48	212,180	35,600	5.96	1,955	18.21	23,150	1,730	13.38
86	July 12	19.85	187,960	33,900	5.54	1,926	17.60	22,600	1,720	13.14
87	July 14	18.61	157,160	30,790	5.10	1,899	16.21	21,930	1,725	12.71
88	July 15	18.41	159,630	30,810	5.18	1,892	16.28	22,420	1,720	13.03
89	July 16	18.01	152,440	29,970	5.09	1,879	15.95	23,360	1,718	13.02
90	July 18	17.00	131,300	26,980	4.87	1,770	15.24	21,260	1,708	12.45
91	July 19	16.77	128,400	26,220	4.90	1,770	14.81	21,090	1,700	12.41
92	July 21	16.47	127,850	25,260	5.06	1,785	14.15	20,470	1,730	11.83
93	July 22	16.32	126,020	25,980	4.85	1,779	14.60	21,410	1,695	12.63
94	July 24	16.63	127,810	26,220	4.87	1,784	14.70	21,250	1,700	12.50
95	July 25	17.07	131,250	27,330	4.80	1,788	15.28	21,490	1,695	12.68
96	July 26	17.65	142,660	28,370	5.03	1,793	15.82	21,480	1,690	12.71
97	July 28	17.07	133,300	26,170	5.09	1,789	14.63	20,100	1,668	12.05
98	July 29	16.36	121,490	25,130	4.83	1,782	14.10	20,470	1,677	12.21
99	July 30	16.25	114,960	24,790	4.64	1,783	13.90	20,360	1,670	12.19
100	July 31	15.94	113,720	23,670	4.80	1,775	13.33	19,690	1,660	11.86
101	Aug. 1	15.77	110,330	23,130	4.77	1,768	13.08	19,580	1,655	11.83
102	Aug. 2	15.61	107,750	23,470	4.59	1,760	13.27	20,250	1,665	12.16
103	Aug. 4	15.88	109,330	23,610	4.63	1,772	13.32	20,060	1,665	12.05
104	Aug. 5	15.79	112,230	24,360	4.61	1,771	13.76	20,800	1,670	12.45
105	Aug. 6	16.13	124,210	25,430	4.88	1,777	14.31	21,360	1,660	12.87
106	Aug. 7	16.25	130,310	25,980	5.02	1,778	14.61	21,620	1,660	13.02
107	Aug. 8	15.83	116,920	23,720	4.93	1,772	13.38	19,860	1,640	12.11
108	Aug. 9	15.23	108,370	23,560	4.60	1,754	13.43	20,940	1,650	12.69
109	Aug. 11	14.44	96,350	20,970	4.59	1,696	12.36	19,820	1,550	12.79
110	Aug. 12	13.89	96,240	20,420	4.71	1,667	12.25	20,180	1,645	12.27
111	Aug. 14	13.39	84,830	19,610	4.33	1,551	12.64	20,280	1,645	12.33
112	Aug. 16	12.65	77,740	18,740	4.15	1,525	12.29	20,920	1,645	12.72
113	Aug. 18	12.05	67,430	17,050	3.96	1,486	11.47	19,730	1,640	12.03
114	Aug. 19	11.77	68,780	17,410	3.95	1,476	11.79	20,490	1,640	12.49
115	Aug. 20	11.62	67,430	17,520	3.85	1,473	11.89	20,730	1,640	12.64
116	Aug. 21	11.41	68,780	17,830	3.82	1,467	11.81	21,040	1,640	12.83
117	Aug. 22	11.22	67,430	16,740	3.67	1,460	11.46	20,630	1,640	12.58
118	Aug. 23	11.02	62,920	17,030	3.69	1,456	11.69	21,800	1,640	12.99
119	Aug. 26	10.37	54,450	15,410	3.53	1,437	10.72	20,630	1,640	12.58
120	Aug. 27	10.23	56,240	16,150	3.48	1,428	11.31	21,620	1,640	13.17
121	Aug. 28	10.00	55,070	16,000	3.44	1,425	11.23	21,720	1,640	13.24
122	Aug. 29	9.91	53,240	15,780	3.37	1,422	11.10	21,650	1,640	13.20
123	Aug. 30	9.78	51,590	15,560	3.32	1,421	10.95	21,540	1,640	13.14
124	Sept. 2	9.25	45,600	14,670	3.11	1,339	10.95	21,520	1,640	13.12
125	Sept. 3	9.10	45,850	14,360	3.19	1,335	10.76	21,200	1,640	12.93
126	Sept. 4	8.96	43,780	13,950	3.14	1,333	10.47	21,380	1,640	13.04
127	Sept. 5	8.81	42,150	13,240	3.18	1,319	10.04	20,670	1,640	12.60
128	Sept. 6	8.70	42,410	13,750	3.08	1,315	10.46	21,100	1,640	12.87
129	Sept. 8	8.47	39,220	12,670	3.10	1,306	9.70	20,746	1,640	12.65
130	Sept. 9	8.33	39,360	12,670	3.11	1,300	9.75	20,780	1,640	12.67
131	Sept. 10	8.23	40,540	12,790	3.17	1,299	9.85	21,130	1,640	12.88
132	Sept. 11	8.43	41,520	12,950	3.21	1,302	9.95	20,914	1,640	12.75
133	Sept. 12	8.88	46,070	12,880	3.58	1,325	9.72	21,160	1,640	12.90
134	Sept. 13	8.70	42,690	13,490	3.16	1,316	10.25	21,130	1,640	12.88
135	Sept. 15	8.47	42,960	13,320	3.22	1,307	10.19	21,330	1,640	13.01
136	Sept. 16	8.47	42,430	13,300	3.19	1,309	10.16	21,110	1,640	12.87
137	Sept. 17	8.65	44,890	13,370	3.33	1,314	10.17	21,150	1,640	12.90
138	Sept. 18	8.56	39,890	12,530	3.18	1,312	9.55	20,340	1,640	12.40
139	Sept. 19	8.33	39,670	12,420	3.19	1,299	9.56	20,420	1,640	12.45
140	Sept. 20	8.01	36,090	11,770	3.07	1,281	9.19	20,290	1,640	12.37

*Gauging section changed.

Missouri River—Discharge observations at Saint Charles, Mo.—Continued.

No.	Date.	Gauge-readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
								Area.	Width.	Mean depth.
	1879.	*Feet.*	*Cu. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*
141	Sept. 22	7.41	33,370	11,160	2.99	1,271	8.78	20,350	1,640	12.41
142	Sept. 23	7.38	33,680	10,760	3.13	1,271	8.47	20,170	1,640	12.26
143	Sept. 24	7.33	32,340	10,600	3.05	1,271	8.34	20,040	1,640	12.22
144	Sept. 25	7.23	32,620	10,410	3.13	1,248	8.34	19,880	1,640	12.12
145	Sept. 26	7.10	33,200	10,280	3.23	1,244	8.26	19,850	1,640	12.10
146	Sept. 27	6.99	30,590	9,910	3.09	1,242	7.98	19,570	1,640	11.93
147	Sept. 29	6.84	28,050	9,260	3.03	1,239	7.47	19,250	1,640	11.73
148	Sept. 30	6.84	30,250	9,570	3.16	1,238	7.73	19,520	1,640	11.90
149	Oct. 2	6.61	28,690	9,390	3.06	1,230	7.63	19,440	1,640	11.85
150	Oct. 3	6.79	29,010	9,940	2.92	1,232	8.07	19,860	1,640	12.11
151	Oct. 4	7.03	30,030	10,300	2.92	1,243	8.29	19,890	1,640	12.13
152	Oct. 6	6.71	29,920	10,350	2.89	1,234	8.39	20,330	1,640	12.39
153	Oct. 7	6.84	29,600	10,670	2.77	1,236	8.63	20,590	1,640	12.55
154	Oct. 8	6.77	30,450	10,730	2.84	1,235	8.69	20,640	1,640	12.58
155	Oct. 9	6.67	28,580	10,330	2.77	1,229	8.40	20,400	1,640	12.44
156	Oct. 10	6.58	27,820	10,020	2.78	1,225	8.18	20,220	1,640	12.33
157	Oct. 11	6.53	28,330	9,910	2.86	1,225	8.09	20,070	1,640	12.24
158	Oct. 13	6.79	29,960	10,240	2.93	1,234	9.30	20,180	1,640	12.30
159	Oct. 14	6.94	31,160	10,460	2.98	1,252	9.35	20,000	1,640	12.20
160	Oct. 15	6.89	32,600	10,560	3.09	1,240	8.52	20,200	1,640	12.32
161	Oct. 16	6.84	30,490	10,340	2.95	1,236	8.37	19,960	1,640	12.17
162	Oct. 17	6.74	29,800	10,370	2.87	1,232	8.42	20,370	1,640	12.42
163	Oct. 18	6.57	27,950	9,960	2.81	1,227	8.12	20,240	1,640	12.34
164	Oct. 20	6.57	29,210	9,850	2.97	1,223	8.05	19,950	1,640	12.16
165	Oct. 21	6.57	31,330	10,500	2.99	1,231	8.53	20,500	1,640	12.50
166	Oct. 22	6.79	31,490	10,300	3.06	1,239	8.31	20,150	1,640	12.28
167	Oct. 23	7.03	33,400	10,790	3.10	1,242	8.69	20,400	1,640	12.44
168	Oct. 24	7.23	33,540	10,610	3.16	1,247	8.51	20,030	1,640	12.21
169	Oct. 25	7.13	34,190	11,120	3.07	1,248	8.91	20,490	1,640	12.49
170	Oct. 27	6.68	30,110	9,920	3.04	1,229	8.07	19,740	1,640	12.04
171	Oct. 28	6.48	27,010	9,500	2.84	1,223	7.77	19,710	1,640	12.02

Missouri River—Discharge observations at Kansas City, Mo.

No.	Date.	Gauge readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
								Area.	Width.	Mean depth.
	1883.	*Feet.*	*Cu. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*
1	June 23	325.99	340,818	54,931	6.20	2,181	25.17	44,090	2,181	20.21
2	June 28	326.98	370,295	59,544	6.22	2,184	27.26	46,487	2, 83	21.29
3	June 30	326.11	345,912	58,532	5.91	2,193	26.69	47,339	2,188	21.64
4	July 2	321.97	322,144	54,935	5.86	2,195	25.03	46,233	2,189	21.12
5	July 5	321.94	256,506	48,963	5.24	2,201	22.25	46,896	2,197	21.34
6	July 6	321.62	243,730	48,917	4.98	2,203	22.21	47,553	2,200	21.62
7	July 7	321.86	261,614	50,288	5.20	2,204	22.82	48,304	2,200	22.00
8	July 9	321.66	263,622	49,685	5.31	2,203	22.55	48,231	2,202	21.90
9	July 10	321.66	251,090	48,759	5.15	2,208	22.08	47,303	2,204	21.46
10	July 11	321.88	244,575	49,213	4.97	2,207	22.30	47,272	2,205	21.44
11	July 12	322.95	282,709	52,090	5.43	2,207	23.60	47,092	2,201	21.40
12	July 17	320.82	219,548	44,098	4.98	2,201	20.03	44,494	2,200	20.22
13	July 18	320.17	200,931	43,325	4.64	2,202	19.67	45,152	2,200	20.52
14	July 20	318.77	175,066	39,961	4.38	2,198	18.18	44,645	2,200	20.29
15	July 21	318.30	165,277	39,242	4.21	2,198	17.85	45,179	2,200	20.54
16	July 24	317.08	132,670	32,623	4.07	2,189	14.90	41,225	2,200	18.74
*17	July 27	316.2	114,700	29,510	3.89	1,287	22.93	26,648	1,268	21.02
18	July 28	316.22	117,952	29,928	3.94	1,287	23.25	27,109	1,253	21.63
19	July 31	316.76	121,909	29,310	4.16	1,301	22.53	25,776	1,260	21.46
20	Aug. 1	316.13	119,354	29,040	4.11	1,235	23.14	26,390	1,233	21.40
21	Aug. 2	315.50	106,880	28,075	3.81	1,250	22.46	26,206	1,242	21.10
22	Aug. 3	315.12	108,427	26,965	4.02	1,247	21.62	25,572	1,240	20.62
23	Aug. 4	315.10	111,505	27,440	4.06	1,249	21.97	26,063	1,244	20.96
24	Aug. 6	315.02	105,148	26,690	3.94	1,249	21.37	25,419	1,243	20.45
25	Aug. 7	314.32	93,058	25,210	3.69	1,232	20.46	24,816	1,231	20.16
26	Aug. 8	313.47	90,074	25,218	3.57	1,232	20.47	25,255	1,232	20.50
27	Aug. 11	313.97	88,985	24,328	3.66	1,231	19.76	24,365	1,232	19.77

*Gauging section changed.

Missouri River—Discharge observations at Kansas City, Mo.—Continued.

No.	Date.	Gauge-readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
								Area.	Width.	Mean depth.
	1883.	*Feet.*	*Cu. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*
28	Aug. 13	313.72	84,023	24,253	3.43	1,230	19.72	24,598	1,232	19.97
29	Aug. 14	313.94	94,467	25,059	3.77	1,235	20.29	25,133	1,236	20.33
30	Aug. 16	313.87	88,826	23,256	3.82	1,235	18.83	23,417	1,236	18.95
31	Aug. 17	313.92	88,360	22,980	3.85	1,235	18.57	23,635	1,236	19.12
32	Aug. 20	315.72	121,608	26,490	4.59	1,255	21.11	24,873	1,271	19.57
33	Aug. 23	314.52	97,817	23,667	4.13	1,243	19.04	23,622	1,240	19.05
34	Aug. 24	313.88	89,687	22,704	3.95	1,230	18.46	22,852	1,232	18.55
35	Aug. 27	312.97	80,293	21,812	3.68	1,221	17.86	23,075	1,232	18.73
36	Aug. 28	312.72	71,486	20,840	3.43	1,220	17.08	22,409	1,232	18.19
37	Aug. 30	312.20	67,850	20,862	3.25	1,220	17.10	23,069	1,232	18.72
38	Sept. 1	311.82	65,694	20,547	3.20	1,207	17.02	23,205	1,232	18.84
39	Sept. 3	311.47	58,974	19,624	3.00	1,210	16.22	22,713	1,232	18.44
40	Sept. 5	311.07	57,186	19,248	2.97	1,205	15.97	22,818	1,232	18.52
41	Sept. 6	310.78	53,139	18,964	2.80	1,208	15.70	22,892	1,232	18.58
42	Sept. 7	310.49	52,727	18,805	2.80	1,204	15.62	23,080	1,232	18.73
43	Sept. 10	309.94	46,340	18,571	2.50	1,201	15.46	23,510	1,232	19.08
44	Sept. 11	309.82	47,043	18,609	2.53	1,202	15.48	23,696	1,232	19.23
45	Sept. 12	309.67	48,078	18,764	2.56	1,201	15.62	24,031	1,232	19.51
46	Sept. 13	309.44	44,805	18,247	2.43	1,201	15.19	23,794	1,232	19.31
47	Sept. 14	309.32	43,593	18,108	2.41	1,203	15.05	23,806	1,232	19.32
48	Sept. 15	309.22	41,781	17,499	2.39	1,195	14.64	23,290	1,232	18.91
49	Sept. 17	309.09	41,336	17,301	2.83	1,191	14.53	23,249	1,232	18.87
50	Sept. 19	309.02	41,490	16,993	2.44	1,189	14.29	23,021	1,232	18.69
51	Sept. 20	308.92	38,440	16,551	2.32	1,189	13.92	22,700	1,233	18.42
52	Sept. 21	308.72	41,878	16,570	2.47	1,189	13.94	22,961	1,233	18.64
53	Sept. 24	308.65	38,577	15,851	2.43	1,192	13.30	22,835	1,232	18.53
54	Sept. 26	308.82	42,210	15,983	2.64	1,193	13.40	22,254	1,232	18.07
55	Sept. 27	308.98	43,020	16,062	2.68	1,193	13.46	22,149	1,232	17.98
56	Sept. 28	309.07	40,521	15,820	2.56	1,193	13.26	21,798	1,232	17.69
57	Oct. 5	309.88	43,911	15,950	2.75	1,200	13.29	21,568	1,232	17.51
58	Oct. 6	309.89	43,156	15,730	2.74	1,200	13.11	21,336	1,232	17.32
59	Oct. 9	309.58	43,217	15,799	2.74	1,201	13.16	21,176	1,232	17.19
60	Oct. 11	309.25	40,401	15,440	2.62	1,196	12.91	21,206	1,232	17.21
61	Nov. 6	309.92	50,348	15,577	3.23	1,205	12.93	20,548	1,232	16.68

Kaw River—Discharge Observations at Kansas City, Mo.

No.	Date.	Gauge-reading above Saint Louis directrix.		Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
		Local gauge.	Kansas City gauge.						Area.	Width.	Mean depth.
	1883.	*Feet.*	*Feet.*	*Cu. feet.*	*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Feet.*	*Feet.*
1	July 25	318.27	316.77	4,418	5,946	0.74	585	10.16	5,961	585	10.19
2	Aug. 2	316.90	315.42	7,936	4,016	1.98	536	7.10	4,805	585	8.21
3	Aug. 7	315.85	314.55	5,891	3,186	1.85	546	5.83	4,578	585	7.83
4	Aug. 11	315.32	314.00	4,165	2,791	1.49	532	5.25	4,459	585	7.62
5	Aug. 14	315.18	313.84	5,164	2,885	1.79	533	5.42	4,595	585	7.85
6	Aug. 18	315.29	313.98	4,758	2,873	1.66	532	5.40	4,587	585	7.84
7	Aug. 21	317.20	315.88	12,345	3,919	3.15	573	6.84	4,539	585	7.76
8	Aug. 28	314.53	312.84	5,682	2,721	2.09	543	5.01	4,633	585	7.92
9	Aug. 31	313.74	312.07	4,670	2,317	2.02	5 2	4.52	4,803	585	8.21
10	Sept. 3	313.18	311.48	4,119	2,023	2.01	406	4.98	4,801	585	8.21
11	Sept. 8	312.22	310.26	3,012	1,663	1.81	383	4.31	4,780	585	8.17
12	Sept. 11	311.80	309.88	2,686	1,478	1.82	364	4.06	4,849	585	8.29
13	Sept. 15	311.45	309.20	2,546	1,294	1.97	356	3.63	4,813	585	8.23
14	Sept. 18	311.35	309.08	2,231	1,272	1.75	340	3.74	4,836	585	8.27
15	Sept. 25	310.95	308.70	1,914	1,106	1.78	332	3.33	4,598	585	7.86
16	Sept. 29	310.85	308.98	2,021	1,091	1.85	333	3.23	4,618	585	7.89
17	Oct. 3	311.45	308.92	3,118	1,364	2.29	340	4.01	4,572	585	7.82
18	Oct. 10	311.60	309.49	2,831	1,425	1.99	341	4.18	4,718	585	8.06
19	Oct. 13	311.30	308.90	2,496	1,314	1.90	333	3.95	4,732	585	8.09

Missouri River—Discharge Observations at Atchison, Kans.

No.	Date.	Guage-readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements.		
								Area.	Width.	Mean depth.
	1882.	Feet.	Cu. feet.	Sq. feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Feet.
1	June 7	360.90	66,899	17,206	3.89	1,169	14.72	27,581	1,411	19.55
2	June 8	360.80	61,062	17,017	3.59	1,160	14.56	27,610	1,411	19.57
3	June 9	360.75	63,885	16,403	3.89	1,161	14.13	26,871	1,411	19.04
4	June 10	361.00	63,687	16,018	3.98	1,163	13.77	26,049	1,411	18.46
5	June 12	361.25	70,113	16,800	4.17	1,164	14.43	26,500	1,411	18.78
6	June 13	362.20	83,847	17,592	4.88	1,178	14.93	26,092	1,411	18.49
7	June 14	363.60	101,298	18,737	5.41	1,283	14.64	25,612	1,411	18.15
8	June 16	363.80	100,021	19,097	5.27	1,284	14.87	25,909	1,411	18.36
9	June 17	364.00	97,609	19,001	5.14	1,286	14.77	25,532	1,411	18.09
10	June 19	365.40	154,972	23,825	6.50	1,334	17.86	28,481	1,411	20.18
11	June 21	366.50	175,168	23,930	7.32	1,342	17.83	27,180	1,411	19.26
12	June 22	366.60	172,848	23,773	7.27	1,356	17.53	26,804	1,411	19.00
13	June 28	367.90	183,543	27,848	6.70	1,408	19.78	29,115	1,411	20.63
14	June 29	368.70	196,810	28,960	6.80	1,409	20.55	29,735	1,411	21.07
15	June 30	368.55	216,834	29,713	7.30	1,413	21.03	30,066	1,411	21.31
16	July 1	368.50	218,526	29,663	7.37	1,412	21.01	30,086	1,411	21.32
17	July 3	368.80	223,679	30,777	7.27	1,411	21.81	30,776	1,411	21.81
18	July 4	368.75	193,525	27,929	6.93	1,414	19.75	28,008	1,411	19.85
19	July 6	367.70	171,242	28,843	5.94	1,402	20.57	30,343	1,411	21.50
20	July 7	367.10	164,275	27,111	6.06	1,376	19.70	29,611	1,411	20.99
21	July 8	366.75	163,378	27,193	6.01	1,354	20.08	30,101	1,411	21.33
22	July 11	365.70	131,149	26,091	6.03	1,341	19.46	30,372	1,411	21.53
23	July 12	365.40	140,206	26,029	5.39	1,342	19.40	30,904	1,411	21.90
24	July 13	365.55	134,019	25,917	5.17	1,344	19.28	30,229	1,411	21.42
25	July 14	365.65	140,849	27,004	5.20	1,344	20.09	31,066	1,411	22.02
26	July 17	365.70	147,606	25,516	5.78	1,347	18.94	29,828	1,411	21.14
27	July 18	365.85	147,786	24,471	6.04	1,347	18.17	28,627	1,411	20.29
28	July 21	364.70	112,053	22,222	5.04	1,291	17.21	27,878	1,411	19.76
29	July 22	364.40	101,769	21,992	4.63	1,291	17.08	28,304	1,411	20.06
30	July 24	363.65	89,192	20,904	4.27	1,278	16.36	27,841	1,411	19.73
31	July 25	363.20	86,208	20,628	4.18	1,254	16.45	28,034	1,411	19.87
32	July 26	362.95	85,112	20,372	4.18	1,248	16.32	28,090	1,411	19.91
33	July 27	362.70	79,230	19,495	4.08	1,244	15.60	27,628	1,411	19.58
34	July 28	362.45	79,689	18,797	4.24	1,237	15.20	27,109	1,411	19.21
35	July 29	362.25	78,100	18,175	4.30	1,231	14.76	26,648	1,411	18.88
36	July 31	362.25	79,169	17,180	4.61	1,226	14.01	25,742	1,411	18.24
37	Aug. 24	358.55	38,966	11,818	3.30	1,054	11.21	24,568	1,411	17.41
38	Aug. 25	358.45	38,269	11,211	3.40	1,014	10.77	24,022	1,411	17.02
39	Aug. 26	358.40	37,248	11,939	3.12	1,059	11.27	24,970	1,411	17.70
40	Aug. 28	358.25	38,406	11,731	3.27	1,056	11.11	25,043	1,411	17.75
41	Aug. 29	358.27	38,213	11,973	3.19	1,064	11.25	25,004	1,411	17.72
42	Aug. 30	358.22	39,456	11,642	3.39	1,061	10.97	24,673	1,411	17.49
43	Aug. 31	358.23	38,377	11,759	3.26	1,061	11.08	25,009	1,411	17.72
44	Sept. 1	358.22	37,323	11,540	3.23	1,059	10.90	24,727	1,411	17.52
45	Sept. 2	358.15	34,571	10,890	3.17	1,060	10.27	23,952	1,411	16.98
46	Sept. 4	358.00	34,413	10,371	3.32	1,058	9.80	23,983	1,411	16.96
47	Sept. 5	357.90	34,026	10,496	3.24	1,051	9.98	24,121	1,411	17.09
48	Sept. 6	357.82	32,161	10,259	3.13	1,048	9.79	24,009	1,411	17.02
49	Sept. 7	357.75	32,730	10,306	3.17	1,048	9.83	24,149	1,411	17.11
50	Sept. 8	357.65	31,003	10,138	3.06	1,043	9.72	24,013	1,411	17.02
51	Sept. 9	357.58	31,766	10,709	2.97	1,043	10.27	24,646	1,411	17.47
52	Sept. 11	357.42	29,159	9,974	2.92	1,039	9.60	24,286	1,411	17.21
53	Sept. 12	357.83	29,561	10,164	2.91	1,083	9.79	24,507	1,411	17.37
54	Sept. 13	357.20	30,529	10,601	2.88	1,035	10.24	24,943	1,411	17.66
55	Sept. 14	357.15	28,166	10,265	2.74	1,031	9.96	24,633	1,411	17.46
56	Sept. 19	356.78	26,494	9,916	2.67	1,022	9.70	24,663	1,411	17.48
57	Sept. 20	356.70	25,928	9,354	2.77	1,023	9.14	24,231	1,411	17.17
58	Sept. 21	356.66	24,783	9,349	2.65	1,021	9.16	23,974	1,411	16.99
59	Sept. 22	356.65	24,943	9,351	2.67	1,018	9.19	24,226	1,411	17.17
60	Sept. 23	356.58	24,514	9,001	2.72	1,012	8.99	24,001	1,411	17.01
61	Sept. 25	356.47	22,899	8,860	2.58	1,014	8.74	24,110	1,411	17.09
62	Sept. 26	356.42	23,016	8,847	2.60	1,014	8.72	24,065	1,411	17.06
63	Sept. 27	356.40	22,993	8,845	2.60	1,014	8.72	24,313	1,411	17.23
64	Sept. 29	356.42	23,291	8,838	2.63	1,013	8.72	24,119	1,411	17.09
65	Sept. 30	356.40	23,356	8,858	2.64	1,013	8.74	24,018	1,411	17.02
66	Oct. 2	356.40	22,858	8,883	2.57	1,012	8.78	24,133	1,411	17.10
67	Nov. 29	355.64	18,980	7,318	2.59	796	9.19	23,036	1,411	16.83

Missouri River—Discharge observations at Saint Joseph, Mo.

No.	Date.	Gauge-readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elemen[ts]	
								Area.	Width.
	1878.	Feet.	Cu. feet.	Sq. feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.
1	Oct. 8	386.15	39,880	15,300	2.61	1,220	12.54	15,300	1,220
2	Oct. 9	386.15	37,745	15,600	2.42	1,238	12.60	15,600	1,238
3	Oct. 10	386.15	34,335	13,900	2.47	1,170	11.90	13,900	1,170
4	Oct. 11	386.23	36,863	14,200	2.60	1,175	12.09	14,106	1,174
5	Oct. 12	386.02	31,066	13,500	2.31	1,175	11.50	13,653	1,177

Missouri River—Discharge observations at Nebraska City, Nebr.

No.	Date.	Guage-readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum eleme[nts]	
								Area.	Width.
	1878.	Feet.	Cu. feet.	Sq. feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.
1	May 10	499.60	48,582	13,173	3.69	1,890	6.97	28,226	2,82[illegible]
2	May 24	501.30	91,950	18,530	4.96	2,195	8.44	29,560	2,82[illegible]
3	May 29	501.70	114,300	23,040	4.96	2,340	9.84	32,963	2,825
4	May 31	501.50	104,680	21,130	4.95	2,060	10.25	31,895	2,8[illegible]
5	June 2	500.84	88,880	20,040	4.44	2,020	9.92	32,100	2,[illegible]
6	June 5	500.34	74,760	20,200	3.70	2,045	9.87	33,306	2,[illegible]25
7	June 7	500.04	62,240	14,900	4.18	1,490	10.00	28,680	2,825
8	June 10	499.99	60,320	14,260	4.23	1,470	9.70	28,146	2,825
9	June 13	501.64	116,840	18,220	6.41	2,135	8.53	28,390	2,825
10	June 15	501.89	118,200	18,580	6.36	2,160	8.60	27,937	2,825
11	June 20	504.34	199,600	31,340	6.37	2,800	11.19	33,871	2,825
12	June 22	504.64	209,280	30,580	6.84	2,810	10.88	32,269	2,825
13	June 24	504.94	201,640	30,340	6.64	2,820	10.76	31,287	2,825
14	June 26	505.14	214,680	29,140	7.37	2,810	10.37	29,423	2,825
15	June 28	505.14	239,640	29,800	7.10	2,830	10.53	30,063	2,825
16	June 30	505.24	209,800	28,660	7.32	2,825	10.14	28,660	2,825
17	July 3	505.04	175,880	27,460	6.04	2,840	9.67	28,032	2,825
18	July 7	503.84	143,120	28,440	5.03	2,850	9.98	32,444	2,825
19	July 10	503.49	125,400	28,840	4.35	2,830	10.12	33,814	2,825
20	July 12	503.54	150,040	30,560	4.91	2,840	10.76	35,379	2,825
21	July 14	503.54	143,000	30,860	4.63	2,845	10.84	35,694	2,825
22	July 17	503.49	146,200	28,440	5.14	2,830	9.98	33,413	2,825
23	July 19	502.84	123,480	26,580	4.65	2,850	9.32	33,432	2,825
24	July 21	502.44	108,600	23,900	4.55	2,840	8.41	31,880	2,825
25	July 24	501.69	88,800	20,920	4.25	2,840	7.37	31,002	2,825
26	July 31	500.90	72,600	19,860	3.65	2,825	7.03	31,120	2,825
27	Aug. 12	499.70	50,870	14,760	3.41	2,660	5.55	30,915	2,825
28	Aug. 24	498.60	40,950	11,565	3.97	2,240	5.15	29,373	2,825
29	Aug. 28	498.50	34,530	11,025	3.13	2,260	4.92	29,035	2,825
30	Aug. 31	498.30	35,730	10,860	3.28	2,320	4.68	29,665	2,825
31	Sept. 4	498.10	31,260	10,710	2.92	2,800	3.82	30,908	2,825
32	Sept. 7	497.90	30,270	9,750	3.10	2,480	3.93	30,885	2,825
33	Sept. 26	496.90	21,640	8,920	2.42	1,560	5.72	31,480	2,825

Missouri River—Discharge observations at Omaha, Nebr.

Date.	Gauge readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean depth.	Datum elements. Area.	Datum elements. Width.	Datum elements. Mean depth.
1878.	Feet.	Cu. feet.	Sq. feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Feet.
Oct. 1	553.18	31,866	8,614	3.68	1,000	8.64	8,444	998	8.46
Oct. 2	553.06	29,672	8,717	3.40	955	9.12	8,621	954	9.09
Oct. 3	553.01	26,358	7,285	3.62	815	8.62	7,285	845	8.60
Oct. 10	552.51	17,426	6,532	2.66	810	8.06	6,856	845	8.11
Oct. 11	552.51	21,597	7,332	2.92	820	8.94	7,742	845	9.16
Oct. 12	552.41	23,070	5,426	4.25	670	8.10	5,848	760	7.68
Oct. 14	552.46	19.608	5.312	3.50	620	8.57	5,684	760	7.48
Oct. 18	552.41	24,349	5,858	4.15	680	8.60	6,267	760	8.26
Oct. 22	552.31	19,051	6,850	2.78	740	9.26	7,368	760	9.73
Oct. 28	552.41	24,638	4,397	5.60	434	10.13	4,665	510	9.84
Nov. 6	552.41	20,969	5,426	3.86	485	11.20	5,717	510	11.32
Nov. 9	552,41	22,602	4,892	4.62	470	10.41	5,186	510	10.17
Nov. 12	552.41	22,091	5,316	4.15	675	7.87	5,718	690	8.28
Nov. 14	522.41	24,309	5,838	4.17	675	8.65	6,243	690	9.05
Nov. 15	522.41	24,309	6,344	3.83	675	9.40	6,749	690	9.78
Nov. 16	552.41	24,733	7,179	3.44	680	10.56	7,587	690	10.99
Nov. 19	552.41	22,946	6,745	3.40	1,260	5.35	7,501	1,260	5.79
Nov. 21	552.41	24,006	4,658	5.11	595	7.83	5,015	605	8.29
Nov. 22	552.31	25,330	4,585	5.52	595	7.70	5,019	605	8.29
1879.									
Aug. 26	553.36	37,717	7,681	4.91	932	8.24	7,306	932	7.92
Aug. 30	553.06	30,610	6,789	4.53	920	7.33	6,694	920	7.27
Sept.‡ 2	552.71	27,437	7,368	3.72	910	8.09	7,635	920	8.30
Sept.‡ 4	552.61	26,811	7,351	3.65	890	8.26	7,704	920	8.37
Sept.‡ 22	551.25	17,716	5,479	3.23	1,055	5.19	5,770	1,238	4.66
Sept. 27	551.07	17,336	5,171	3.16	980	5.28	5,689	1,238	4.59
Oct. 3	551.27	17,240	5,502	3.13	1,238	4.46	5,502	1,238	4.44
Oct. [illegible]	551.25	14,612	4,849	3.01	973	4.98	5,144	1,238	4.15
1880.									
April 15	554.01	46,466	9,880	4.70	833	11.86	10,588	833	12.71
April 2[illegible]	554.86	57,486	9,421	6.12	833	10.18	9,420	833	11.34
May 3	553.21	39,133	7,477	5.23	1,270	5.87	9,628	1,840	7.19
May 5	552.94	33,558	5,919	5.67	770	7.32	7,457	833	8.95
Nov. 1	551.36	19,112	4,582	4.17	797	5.75	7,434	833	8.92
1882.									
June 13-15	556.05	109,398	13,927	7.85	1,119	12.44	15,000	1,145	13.10
June 13-15	536.05	113,487	14,502	7.82	1,093	13.26	15,548	1,110	14.00
July 10	557.45	113,408	16,168	7.01	1,160	13.93	15,820	1,160	13.64
July 11-12	557.65	135,292	16,659	8.12	1,160	14.36	16,079	1,160	13.86
July 19	557.05	107,034	13,898	7.70	1,160	11.98	14,072	1,160	12.13
July 22	556.00	*80,673	12,511	6.43	1,160	10.90	13,954	1,160	12.03
July 25	555.06	88,790	12,385	5.55	1,097	11.29	14,763	1,160	12.72
July 26	554.80	64,834	11,455	5.66	1,096	10.45	14,135	1,160	12.18
July 27	554.85	67,747	11,102	6.10	1,093	10.15	14,763	1,160	12.72
Aug. 28	552.52	31,566	7,823	4.03	1,045	7.48	13,060	1,160	11.26
Aug. 29	552.42	33,483	7,922	4.22	1,034	7.66	13,265	1,160	11.43
Aug. 30	552.37	31,197	7,584	4.11	1,035	7.32	13,102	1,160	11.29
Aug. 31	552.28	34,680	7,953	4.35	1,048	7.59	13,455	1,160	11.60
Sept. 1	552.23	30,649	7,636	4.01	1,046	7.29	13,294	1,160	11.49
Sept. 2	552.12	32,690	7,429	4.39	1,049	7.06	13,026	1,160	11.23
Sept. 4	551.91	29.538	6,853	4.27	1,041	6.58	12,738	1,160	10.98
Sept. 5	551.80	28,983	7,246	3.99	1,049	6.90	13,148	1,160	10.33
Sept. 11	551.30	23,628	7,145	3.30	1,045	6.83	13,378	1,160	11.53
Sept. 12	551.17	24,631	7,270	3.38	1,051	6.92	13,886	1,160	12.01
Sept. 13	551.12	24,615	7,261	3.39	1,044	6.95	13,983	1,160	12.05
Sept. 16	551.05	24,387	6,731	3.62	1,044	6.44	13,288	1,160	11.45
Sept. 26	550.76	21,909	6,251	3.55	1,060	6.01	14,130	1,160	12.18
Sept. 27	550.76	16,837	4,920	3.42	1,055	4.66	12,825	1,160	11.06
Sept. 28	550.82	19,682	5,802	3.39	1,053	5.51	13,794	1,160	11.89
Sept. 29	550.80	19,360	5,752	3.43	974	5.90	13,674	1,110	12.32
Sept. 30	550.76	20,816	6,673	3.12	914	7.30	14,364	1,110	12.94
Oct. 2	550.75	21,122	6,030	3.35	900	6.70	13,624	1,110	12.27

*Probably a change of section.

†Gauging sections changed.

Missouri River—Discharge observations at Sioux City, Iowa.

[Figures preceded by an italic *i* indicate interpolated values.]

No.	Date.	Gauge readings above Saint Louis directrix.	Discharge per second.	Area.	Mean velocity per second.	Width.	Mean dedth.	Datum elements.		
								Area.	Width.	Mean depth.
	1878.	Feet.	Cu. feet.	Sq. feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Feet.
1	Sept. 17	668.64	30,319	8,643	3.51	1,130	7.65	8,962	1,125	[illegible]
2	Sept. 18	668.64	30,059	8,453	3.56	1,130	7.48	8,792	1,125	[illegible]
3	Sept. 19	668.59	29,827	8,613	3.46	1,125	7.65	9,007	1,125	[illegible]
4	Sept. 21	668.99	29,535	8,398	3.52	1,127	7.44	8,342	1,125	[illegible]
5	Sept. 26	668.94	27,535	7,958	3.46	1,125	7.08	7,958	1,125	[illegible]
6	Sept. 30	668.94	26,136	8,107	3.22	1,150	7.05	8,107	1,125	[illegible]
7	Oct. 2	668.74	25,748	7,779	3.31	1,115	6.95	8,003	1,125	[illegible]
8	Oct. 3	668.64	25,789	7,565	3.41	1,120	6.75	7,902	1,125	[illegible]
9	Oct. 4	668.64	25,374	7,743	3.28	1,120	6.91	8,060	1,125	[illegible]
10	Oct. 5	668.64	23,606	7,600	3.12	1,125	6.75	7,938	1,125	[illegible]
11	Oct. 7	668.34	22,065	7,054	3.13	1,125	6.27	7,729	1,125	[illegible]
12	Oct. 9	668.24	22,647	7,194	3.15	1,120	6.42	7,978	1,125	[illegible]
13	Oct. 11	668.24	22,940	7,551	3.04	1,123	6.72	8,330	1,125	[illegible]
14	Nov. 1	668.01	20,995	5,951	3.53	1,125	5.29	6,963	1,125	[illegible]
	1879.									
1	July 1	677.41	196,712	26,284	7.48	1,390	18.91	26,284	1,390	[illegible]
2	July 2	677.34	195,058	26,263	7.43	*i* 1,387	*i* 18.93	*i* 26,261	1,390	[illegible]
3	July 5	676.58	157,573	24,850	6.34	*i* 1,385	*i* 17.93	*i* 26,001	1,390	[illegible]
4	July 7	675.94	161,533	24,830	6.51	*i* 1,382	*i* 17.96	*i* 26,867	1,390	[illegible]
5	July 9	675.79	137,443	23,068	5.96	*i* 1,379	*i* 16.73	*i* 25,312	1,390	[illegible]
6	July 10	675.89	124,040	20,497	6.05	*i* 1,376	*i* 14.89	*i* 22,599	1,390	[illegible]
7	July 14	674.76	108,495	20,394	5.32	*i* 1,373	*i* 14.56	*i* 23,054	1,390	[illegible]
8	July 15	674.68	105,542	20,120	5.24	*i* 1,370	*i* 14.69	*i* 23,887	1,390	[illegible]
9	July 16	674.69	105,262	19,967	5.27	*i* 1,367	*i* 14.60	*i* 23,720	1,390	[illegible]
10	July 22	673.57	88,058	16,943	5.20	*i* 1,365	*i* 12.43	*i* 22,211	1,390	[illegible]
11	July 23	673.52	85,020	15,840	5.37	*i* 1,360	*i* 11.65	*i* 21,177	1,390	[illegible]
12	July 24	673.14	81,408	16,387	4.97	*i* 1,357	*i* 12.08	*i* 22,245	1,390	[illegible]
13	July 25	672.76	80,676	15,733	5.12	1,355	11.61	22,112	1,390	[illegible]
14	July 28	673.29	99,222	18,654	5.32	*i* 1,362	*i* 13.70	*i* 24,340	1,390	[illegible]
15	July 30	673.84	100,518	17,706	5.68	*i* 1,370	*i* 12.92	*i* 22,623	1,390	[illegible]
16	Aug. 1	673.54	93,184	14,871	6.27	1,390	10.70	20,258	1,390	[illegible]
17	Aug. 8	670.84	58,259	10,927	5.33	*i* 1,385	*i* 7.90	*i* 19,940	1,390	[illegible]
18	Aug. 13	670.34	46,371	10,993	4.22	*i* 1,377	*i* 7.91	*i* 20,771	1,390	[illegible]
19	Aug. 14	670.14	45,570	10,912	4.18	*i* 1,369	*i* 7.97	*i* 20,945	1,390	[illegible]
20	Aug. 15	670.09	40,232	10,705	3.76	*i* 1,361	*i* 7.86	*i* 20,770	1,390	[illegible]
21	Aug. 20	669.54	37,282	9,007	4.12	*i* 1,353	*i* 6.65	*i* 19,797	1,390	[illegible]
22	Aug. 21	669.49	34,022	7,930	4.29	*i* 1,345	*i* 5.89	*i* 18,757	1,390	[illegible]
23	Aug. 26	669.29	31,440	8,138	3.86	*i* 1,104	*i* 7.91	*i* 19,116	1,390	[illegible]
24	Sept. 6	668.39	24,713	6,425	3.85	*i* 1,096	*i* 5.86	*i* 18,425	1,390	[illegible]
25	Sept. 13	667.94	22,810	6,354	3.59	*i* 1,088	*i* 5.84	*i* 18,860	1,390	[illegible]
26	Sept. 19	667.44	18,741	5,548	3.56	1,080	5.14	19,027	1,390	[illegible]

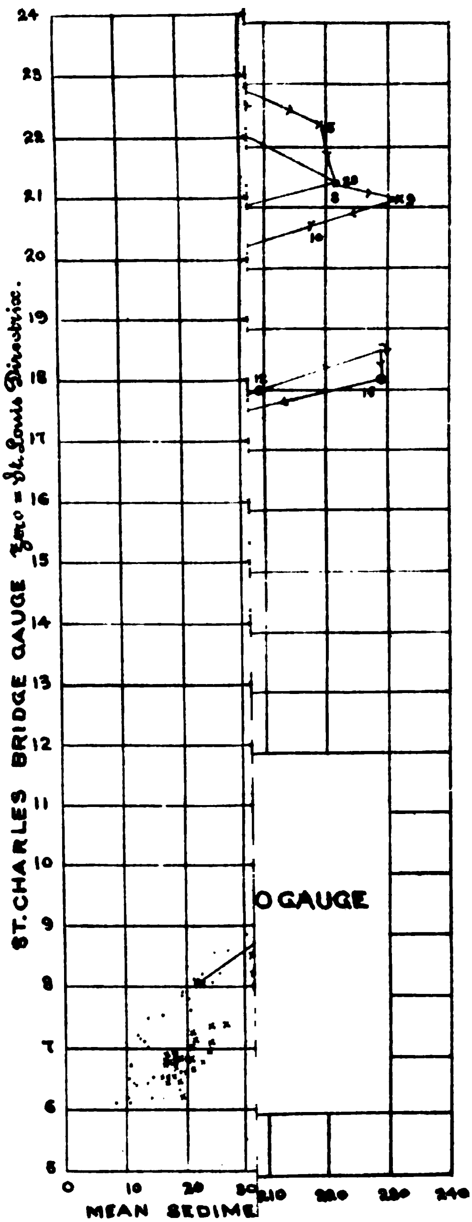
NOTES ON SEDIMENT OBSERVATIONS OF 1879 AT SAINT CHARLES, MISSOURI, BY AS-SISTANT ENGINEER JAMES A. SEDDON.

These sediment observations were made at the discharge sections from about 600 to 1,000 feet above the Saint Charles Bridge.

In the observations eight points about equally distributed across the river were located on the cross-section and at each location samples of water were taken at the surface, at mid-depth, and at 1 foot from bottom. From these samples horizontal and vertical combinations were made as follows: 2 ounces from each of the eight surface samples were taken for a horizontal surface combination and from this the mean surface sediment in milligrammes per pint was determined. In the same way mid-depth and foot-from-bottom combinations were made up and mean sediment determined.

The vertical combinations were made of 2 ounces from each of the three samples selected at one location, viz., surface, mid-depth, and foot from bottom, and from these the mean sediment per pint in the vertical was determined for each of the eight locations. The vertical combinations were made during only a portion of the series, and as nothing of special interest resulted from the study of mean sediment at the different locations, the mean of the eight vertical combinations is alone given in the tabulation.

From the above as data, the method of computing total sediment is apparent in the tabulation. It will be observed that the computation is made on the assumption that there is a mean sediment per cubic foot of water that represents the saturation of the discharge with sediment at that time. Under this assumption the arithmetical mean of the surface, mid-depth, and foot-from-bottom combinations is used as the determination of


ST. CHARLES BRIDGE GAUGE Zero = St. Louis Directrix.
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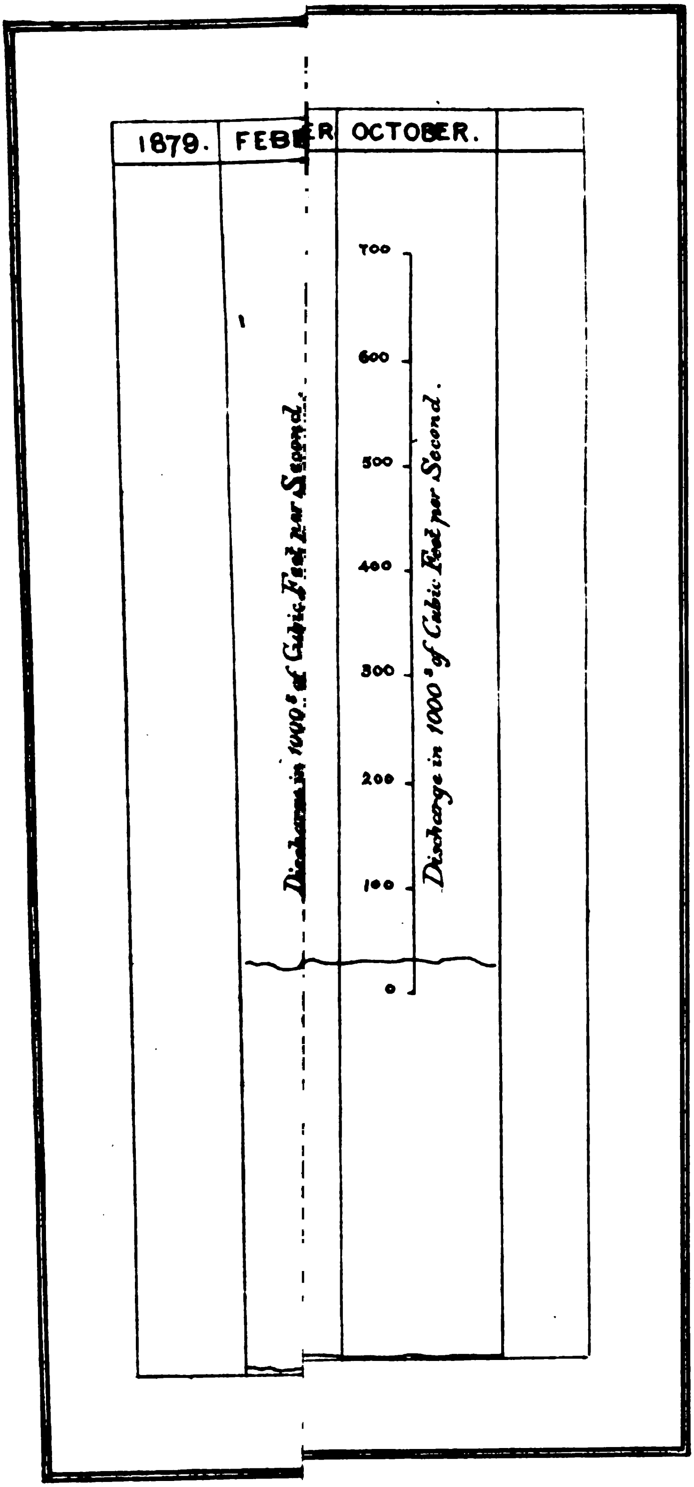
1879.
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ER
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600
500
400
300
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100
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Discharge in 1000s of Cubic Feet per Second.
Discharge in 1000s of Cubic Feet per Second.

this mean sediment when horizontal combinations were alone taken; and where vertical combinations were also taken, the mean of the horizontal and vertical means is used, each having the same weight as an observation, since they each consisted of determinations from the same number of samples.

This method of computation may be questioned, for to the extent that there may be a permanent difference in the sediment per cubic foot in different parts of the cross-section, it must involve some error in determining total sediment, since it is known that there is a considerable difference in the discharge through different parts of the cross-section. It is thought, however, that the sediment data in the main justifies the above method of computation, except perhaps at periods of small mean sediment where minor errors would be immaterial.

The gauge readings given with the tabulation are elevations of water surface at the Saint Charles United States Engineer bridge gauge; on those dates when discharge observations were taken with the sediment they are the elevations accompanying the discharge data; on other dates they are the mean for the day, as with the discharge data they are 1885 reductions to the Saint Louis directrix. Prior to April 3, 1879, there are small discrepancies between the gauge heights given with this data and those in the printed gauge records. This arises from the fact that here all the elevations are deduced from readings on the observation gauge or gauge 2 of the Saint Charles gauge history. So that whatever error may exist in the reduction is common to the whole series, while in the printed gauge records the elevations were taken from readings on gauge 1, until these readings were discontinued April 2, 1879.

On days when mean sediment was not observed interpolations were obtained by scaling values corresponding to the gauge heights on a diagram of observed mean sediment plotted to gauge. This diagram is presented on plate (I). The sediment observations plotted to their corresponding gauge heights are represented for the different months and days by symbols explained on the diagram. Where values were wanted they were scaled for the gauge height on the straight lines connecting the preceding and following observed values. It is apparent from this diagram that besides the variation of mean sediment to gauge there is quite a marked variation to time independent of gauge, but this method of interpolation is considered in the main reasonably close and the only uniform method that is advisable. In the interpolated values of discharge the same method was followed of interpolating to gauge between the observed values. This is the usual method in discharge interpolations.

Several determinations of the specific gravity were made, from which a mean specific gravity for the sediment of 1.6 was deduced; by this the total sediment per day in cubic yards was reduced.

During a portion of the time that these sediment observations were taken at Saint Charles a series of sediment observations were taken on the Mississippi River at Columbus, Ky., and as a comparison of the two presents some points of decided interest, the comparison is here given on plate (2).

To the discharge scale shown, the daily variation of discharge in cubic feet per second at Saint Charles is drawn in black, and the dotted line above is the daily variation of discharge at Columbus to the same scale. An interval of three days is allowed between Saint Charles and Columbus, so that the Columbus discharges are plotted to dates three days earlier than their actual time, to correspond with Saint Charles dates. From March 10 to 30 a line is drawn among the Columbus discharges, which represents the most probable variation of discharge at Columbus during this time, as from other investigations it is inferred that there is considerable error here in several of the Columbus discharge observations. Since no sediment observations were taken at Columbus during this time, this uncertainty of discharge is here immaterial.

Below the discharge, to the scale of sediment given, are plotted the daily variations of total sediment per second in kilogrammes, Saint Charles in full, Columbus in dots. The Columbus sediment variation is shifted as the discharge to correspond with Saint Charles dates. From inspection of the sediment variation it is at once apparent that the total sediment at Columbus, and hence mean sediment per cubic foot, unlike Saint Charles, has no variation with gauge; for this reason only the points of observed sediment are plotted for Columbus, and such gaps between the observations in which the variation of sediment is very uncertain are shown with light dots.

It is seen on this diagram that the agreement between total sediment at Saint Charles and Columbus is very marked, with the exception of a short period of erratic variation at Columbus early in May; all the variations of total sediment past Saint Charles are very closely reproduced at Columbus. The resulting conclusions are that the sediment carried by water reaching Columbus from other sources than the Missouri is very small indeed in comparison with that reaching it with the Missouri River water; and that at least close to the same amount of sediment that is carried at Saint Charles is carried in the Missouri River water when it reaches Columbus. The inference is, of course, that it is the

same sediment carried in permanent suspension from Saint Charles to Columbus. This is also a further justification of the assumption before mentioned, that there is a mean sediment per cubic foot of water that represents the saturation of the discharge with sediment at any time under which the total sediment was computed.

In regard to the proportions of sediment reaching Columbus from the Missouri and from other sources the ratio of areas included in the sediment variations gives the total sediment past Saint Charles as 86 per. cent of the total sediment past Columbus during their coincident period, which, it is seen, includes only a part of the Missouri River high water.

Besides the above there are several interesting points suggested by the diagram.

The first is in regard to the time interval between Saint Charles and Columbus. Considering the nature of the data and the fact of some independent additions to the sediment between Saint Charles and Columbus, it is thought that the diagram gives very good evidence that sediment, and hence discharge, passing Saint Charles reaches Columbus after about a three days' interval. Second, there is an interesting suggestion in regard to the nature of the passage of discharge from point to point.

The water passing Saint Charles at a given time is to a certain extent identified by a given mean sediment per cubic foot (for in rapid changes the water passing a day before or after may have considerable change in mean sediment) hence for the same total sediment to pass Columbus after a three days' interval, not only must an equal discharge have reached Columbus from Saint Charles, but to a considerable degree the identical discharge.

The theory of flow, in accord with the above, is that the individual masses of water in a given cross-section, though subject to very different velocities at a given instant, are really in different phases of a cycle of velocities, which cycle, to a considerable degree, is the same for all. The data can hardly be said to furnish more than a fair suggestion of this; but even a suggestion on this subject is valuable, for it enters as a primary question in the study of the relations between gauge readings from point to point along the river.

Missouri River sediment observations, Saint Charles, Mo.

Date.	Gauge-reading above Saint Louis directrix.	Sediment in milligrams per pint.						Mean sediment (in grams, per cubic foot).		Discharge (in cubic feet per second).		Total sediment	
		Horizontal combination.				Vertical combination, mean.	Resulting mean.						
		Surface.	Mid-depth.	Foot from bottom.	Mean.			Observed.	Interpolated.	Observed.	Interpolated.	Per second in kilograms.	Per day in cubic yards.
1879.	*Feet.*												
Feb. 1	8.27	....	....	....	....	....	....	....	21.80	....	42,300	922.1	[illegible]
2	8.52	....	....	....	....	....	....	....	24.00	....	44,300	1,063.2	[illegible]
3	8.05	....	....	....	....	....	....	....	20.20	....	40,700	822.1	[illegible]
4	7.77	....	....	....	....	....	....	....	18.00	....	38,800	698.4	[illegible]
5	8.22	....	....	....	....	....	....	....	21.50	....	42,000	903.0	[illegible]
6	7.94	282	341	346	323	....	323	19.33	....	40,000	....	773.2	[illegible]
7	7.53	243	....	293	268	....	268	16.04	....	....	37,000	593.4	[illegible]
8	7.50	218	231	237	227	....	227	13.58	....	36,370	....	494.0	[illegible]
9	7.15	....	....	....	....	....	....	....	12.10	....	34,300	415.0	[illegible]
10	7.17	156	208	241	202	....	202	12.09	....	....	34,700	419.5	[illegible]
11	7.20	190	135	268	198	....	198	11.89	....	....	35,000	416.3	[illegible]
12	7.31	....	....	....	....	....	....	....	12.00	....	36,000	432.0	[illegible]
13	8.36	....	....	....	....	....	....	....	12.00	45,990	....	551.8	[illegible]
14	8.12	....	....	....	....	....	....	....	12.00	....	44,000	528.0	[illegible]
15	7.75	....	....	....	....	....	....	....	12.00	....	40,500	484.8	[illegible]
16	7.63	....	....	....	....	....	....	....	12.00	....	39,600	475.2	[illegible]
17	6.82	....	....	....	....	....	....	....	12.50	....	32,100	401.2	[illegible]
18	6.43	195	217	259	224	....	224	13.40	....	....	28,600	383.3	[illegible]
19	6.17	197	259	270	242	....	242	14.48	....	25,700	....	372.2	[illegible]
20	6.03	145	172	196	171	....	171	10.23	....	24,060	....	246.2	[illegible]
21	6.13	130	157	128	138	....	138	8.26	....	....	24,700	203.9	[illegible]
22	6.51	146	183	199	176	....	176	10.53	....	....	27,800	292.8	[illegible]
23	6.68	....	....	....	....	....	....	....	10.60	....	28,700	304.2	[illegible]
24	6.73	123	179	231	178	....	178	10.65	....	29,050	....	309.4	[illegible]
25	7.01	150	259	277	229	....	229	13.70	....	32,240	....	441.8	[illegible]
26	7.30	269	319	418	345	....	345	20.65	....	....	34,000	701.9	[illegible]
27	7.06	....	....	....	....	....	....	....	20.00	....	32,600	652.0	[illegible]
28	6.61	283	312	370	322	....	322	19.27	....	....	29,700	572.3	[illegible]
Mar. 1	6.54	216	240	260	239	....	239	14.30	....	29,100	....	416.2	[illegible]
2	6.48	....	....	....	....	....	....	....	13.00	....	28,300	367.9	[illegible]

Missouri River sediment observations, Saint Charles, Mo.—Continued.

Date.	Gauge-reading above Saint Louis directrix.	Sediment in milligrams per pint.						Mean sediment (in grams per cubic foot).		Discharge (in cubic feet per second).		Total sediment.	
		Horizontal combination.				Vertical combination, mean.	Resulting mean.	Observed.	Interpolated.	Observed.	Interpolated.	Per second in kilograms.	Per day in cubic yards.
		Surface.	Mid-depth.	Foot from bottom.	Mean.								
1879.	*Feet.*												
Mar. 3	6.43	179	200	205	195		195	11.67			27,900	322.6	23,021
4	6.25								11.10		26,800	297.5	21,035
5	6.07	151	180	203	178		178	10.65		25,520		271.9	19,224
6	6.14	150	175	196	174		174	10.41			26,600	277.0	19,496
7	6.23								10.70	27,280		291.9	20,640
8	6.43	189	185	205	193		193	11.55		28,340		327.3	23,146
9	6.64								11.80		30,100	355.2	25,115
10	7.10	184	221	234	213		213	12.75			33,300	424.5	30,015
11	7.84	317	342	362	340		340	20.35			38,600	785.5	55,536
12	8.03	360	378	436	391		391	23.40		40,220		941.1	66,547
13	7.94	314	321	353	329		329	19.69		38,780		763.5	53,991
14	7.90								19.00		38,500	731.5	51,725
15	9.02	533	587	589	570		570	34.11		47,230		1,611.1	113,920
16	9.52								40.50		54,000	2,187.0	154,645
17	9.40	706	695	725	709		709	42.43		52,320		2,219.9	156,971
18	9.40								42.40	52,950		2,245.1	158,752
19	9.67	808	687	766	754		754	45.12		60,900		2,747.9	194,310
20	9.83	624	669	711	668		668	39.98		58,240		2,328.2	164,630
21	9.78								39.40	55,580		2,189.8	154,847
22	9.50	591	549	653	598		598	35.79			53,200	1,903.8	134,621
23	9.09								32.10		49,500	1,589.0	112,356
24	8.83	492	492	523	502		502	30.04		46,810		1,406.3	99,439
25	8.60	414	452	476	447		447	26.75		44,780		1,197.9	84,706
26	8.22	395	435	456	429		429	25.67			41,200	1,057.7	74,793
27	8.08	352	429	426	402		402	24.06		39,960		961.1	67,959
28	8.10	329	329	417	358		358	21.42			40,100	859.1	60,751
29	8.20	329	420	390	380		880	22.74			40,800	927.8	65,608
30	7.97								21.80		38,700	843.7	59,656
31	7.64	303	355	368	342		342	20.47		35,220		720.8	50,972
Apr. 1	8.07	348	360	382	363		363	21.72			39,400	855.9	60,524
2	10.40	861	951	1,004	939		939	56.19			62,400	3,506.4	247,945
3	11.52	1,198	1,265	1,396	1,286		1,286	76.96			73,500	5,656.5	399,977
4	11.67	1,333	1,343	1,601	1,426		1,426	85.34		74,740		6,378.3	451,014
5	11.47	1,181	1,316	1,480	1,326		1,326	79.36		74,680		5,926.5	419,072
6	11.25								73.60		74,700	5,497.9	388,764
7	11.64	1,180	1,273	1,215	1,223		1,223	73.19			78,000	5,708.8	403,678
8	12.06	1,205	1,321	1,348	1,291		1,291	77.26			85,800	6,628.9	468,738
9	12.26								80.10		89,700	7,185.0	508,058
10	15.20	1,873	2,097	2,237	2,069		2,069	123.82			145,500	18,056.9	1,273,890
11	17.57								196.50	190,270		37,388.0	2,643,755
12	17.97	3,379	3,395	3,678	3,484		3,484	208.50		204,820		42,704.1	3,019,663
13	18.52								225.50		214,900	48,460.0	3,426,626
14	18.65								229.00		217,600	49,830.4	3,523,570
15	18.14	3,800	3,721	3,964	3,828		3,828	229.08		178,870		40,976.1	2,897,470
16	17.33	3,117	3,212	3,345	3,225		3,225	193.00			163,200	31,504.4	2,227,713
17	16.37	2,640	2,870	3,043	2,851		2,851	170.61			146,000	24,909.8	1,761,400
18	15.58	2,521	2,700	2,679	2,633		2,633	157.57		132,510		20,879.6	1,476,423
19	14.77	2,377	2,412	2,467	2,419		2,419	144.76		118,150		17,103.7	1,209,426
20	14.12								131.80		105,600	13,918.1	984,165
21	13.62	1,906	2,019	2,180	2,035		2,035	121.78			95,800	11,666.8	824,968
22	13.23	1,779	2,802	1,970	2,184		2,184	130.70		87,920		11.491.0	812.547
23	12.84	1,623	1,649	1,772	1,681		1,681	100.60		84,350		8,485.4	600,016
24	12.53	1,575	1,727	1,872	1,725		1,725	103.23			79,800	8,181.1	578,498
25	12.24	1,587	2,124	1,890	1,867		1,867	111.73		75.000		8,379.7	592,537
26	12.11	1,588	1,715	1,744	1,682		1,682	100.66		75,140		7,563.4	534,820
27	11.96	1,560	1,693	1,753	1,669		1,669	99.88			73,400	7,331.1	518,393
28	11.81								95.40		72,200	6,889.3	487,050
29	11.72								92.90	71,550		6,747.0	470,017
30	11.62	1,497	1,473	1,526	1,499		1,499	89.71		70,490		6,323.4	447,134
May 1	11.57	1,625	1,506	1,650	1,594		1,594	95.39		66,170		6,312.0	456,727
2	11.52	1,041	1,441	1,487	1,323		1,323	79.17		66,220		5,242.9	369,880
3	11.37	1,316	1,364	1,536	1,405		1,405	84.08			63,000	5,297.1	374.565
4	11.32								74.20		61,700	4,578.1	323,726
5	11.32	1,209	1,220	1,291	1,240		1,240	74.21		61,700		4,578.6	323,760
6	11.32	1,159	1,207	865	1,077		1,077	64.45		62,220		4,010.2	283,566
7	11.53	1,173	1,160	1,201	1,178		1,178	70.50		62,580		4,411.6	311,952
8	12.24	1,287	1,232	1,404	1,308		1,308	78.28		77,570		6,071.9	429,350
9	12.42	1,425	1,367	1,500	1,431		1,431	85.64		79,690		6,824.4	482,673
10	12.64								94.30		82,500	7,779.7	550,116

Missouri River sediment observations, Saint Charles, Mo.—Continued.

Date.	Gauge-reading above Saint Louis directrix.	Sediment in milligrams per pint. Horizontal combination. Surface.	Horizontal combination. Mid-depth.	Horizontal combination. Foot from bottom.	Horizontal combination. Mean.	Vertical combination, mean.	Resulting mean.	Mean sediment (in grams, per cubic foot). Observed.	Mean sediment. Interpolated.	Discharge (in cubic feet per second). Observed.	Discharge. Interpolated.	Total sediment— Per second in kilograms.	Total sediment— Per day in cubic yards.
1879.	*Feet.*												
May 11	12.84								101.80		84,600	8,611.7	608,942
12	12.76	1,743	1,796	1,887	1,809		1,809	108.26			84,700	9,169.5	648,389
13	12.57	2,213	2,295	1,876	2,128		2,128	127.35		85,110		10,838.6	766,410
14	12.46	2,303	2,262	2,346	2,304		2,304	137.88		87,600		12,078.4	854,077
15	12.51	2,068	2,185	2,290	2,181		2,181	130.52		79,770		10,411.6	736,216
16	12.65	1,827	1,953	2,001	1,927		1,927	115.32		85,580		9,869.0	697,850
17	12.56	1,562	1,568	1,653	1,594		1,594	95.39		86,810		8,280.0	585,551
18	12.44								84.00		85,000	7,140.0	504,879
19	12.41	1,383	1,265	1,414	1,354		1,354	81.03		84,600		6,855.6	484,730
20	12.26	1,190		1,253	1,221		1,221	73.07		72,650		5,308.4	375,363
21	12.34	1,198	1,185	1,271	1,218		1,218	72.89		72,060		5,252.3	371,386
22	12.50	1,404	1,616	1,467	1,496		1,496	89.53		75,010		6,715.3	474,850
23	12.61	1,649	1,703	1,746	1,699		1,699	101.67		78,820		8,014.0	566,690
24	12.41	1,599	1,649	1,623	1,624		1,624	97.19			76,300	7,415.5	524,369
25	12.29								84.00		74,700	6,274.0	443,709
26	12.26	1,322	1,354	1,361	1,346		1,346	80.55		74,220		5,978.3	422,736
27	12.32	1,286	1,272	1,331	1,296		1,296	77.56		72,790		5,645.7	399,201
28	12.50	1,293		1,311	1,302		1,302	77.92		76,960		5,996.5	424,029
29	12.71	1,279	1,267	1,665	1,404		1,404	84.02			78,000	6,553.6	463,419
30	12.97								90.10	78,870		7,106.2	502,498
31	13.20								95.90	83,420		8,000.0	565,690
June 1	13.24								97.00		84,400	8,186.8	578,909
2	13.17								95.10	84,380		8,024.5	567,425
3	14.25								121.50		101,500	12,332.2	872,059
4	14.88								136.60	112,250		15,196.8	1,074,570
5	14.87	2,226	2,272	2,304	2,281		2,281	136.50		108,570		14,820.3	1,047,957
6	15.16								128.30	117,320		15,052.2	1,064,354
7	15.72	1,694	1,910	2,054	1,886		1,886	112.87		121,990		13,768.5	973,569
8	16.31								114.80		129,000	14,809.2	1,047,17
9	16.23	1,956	1,885	1,900	1,914		1,914	114.54		127,950		14,655.5	1,036,30
10	16.00	1,871	1,785	1,833	1,830		1,830	109.51		125,110		13,701.3	968,83
11	15.74								104.20		122,000	12,712.1	898,91
12	16.00								109.50	123,660		13,540.8	957,4
13	16.46								119.20	128,110		15,270.7	1,079,81
14	16.28	2,191	1,794	1,807	1,931		1,931	115.56		133,250		15,398.4	1,088,8
15	16.86								128.60		138,600	17,823.9	1,260,3
16	17.30	3,174	1,800	1,989	2,321		2,321	138.90		142,410		19,780.5	1,398,7
17	17.07	2,439	1,863	1,879	2,060		2,060	123.28		136,750		16,858.4	1,192,0
18	17.63	2,633	2,401	2,335	2,456		2,456	146.98		153,770		22,600.6	1,598,1
19	18.37								159.10		168,000	26,728.8	1,890,0
20	19.12	3,105	2,758	2,720	2,861		2,861	171.21			183,000	31,332.2	2,215,5
21	19.77	3,116	2,808	2,810	2,911		2,911	174.21			196,800	34,283.7	2,424,2
22	19.97								175.20		201,000	35,215.2	2,490,1
23	19.54								173.30	191,520		33,190.4	2,346,9
24	20.26	3,212	3,085	3,071	3,123		3,123	186.89		211,450		39,518.5	2,794,4
25	19.30	3,072	2,984	2,760	2,938		2,938	175.82		179,640		31,584.8	2,233,3
26	19.66								179.80	194,360		34,945.9	2,471,0
27	20.59	3,710	3,949	1,875	3,178		3,178	190.18			215,600	41,0[illegible]3.7	2,899,4
28	21.41	3,701		3,701	3,701		3,701	221.48			236,000	52,2[illegible]0.0	3,696,0
29	22.75								195.00		271,400	52,9[illegible]3.0	3,742,5
30	23.06								189.00	290,270		52,971.0	3,660,35
July 1	22.94								191.20	284,890		54,471.0	3,851,70
2	23.25	3,014	3,181	3,091	3,095		3,095	185.22			290,000	53,712.9	3,798,10
3	23.33								183.60	290,800		53,3[illegible]0.9	3,775,3
4	22.95	3,550	3,529	3,262	3,417		3,447	206.28			277,500	57,243.2	4,047,74
5	22.38		3,649		3,649		3,649	218.37		257,170		56,158.5	3,971,05
6	21.65								22[illegible].30		249,000	54,854.7	3,878,8
7	21.53								220.70	247,550		54,634.3	3,863,2
8	21.38	3,724	3,716	3,645	3,695		3,695	221.12		218,260		48,262.5	3,412,70
9	21.11	3,946	3,898	3,692	3,845		3,845	231.89		222,900		51,689.4	3,655,02
10	20.69	3,777	3,599	3,528	3,635		3,635	217.53		220,400		47,944.5	3,390,2
11	20.48								211.00	212,180		44,770.0	3,165,74
12	19.85								190.10	187,960		35,731.2	2,526,60
13	19.19								168.00		171,200	28,761.6	2,033,78
14	18.61	2,876	2,216	2,370	2,487		2,487	148.83		157,160		23,390.4	1,653,96
15	18.41	3,060	2,563	2,618	2,747		2,747	164.39		159,630		26,241.6	1,855,53
16	18.01	3,068	2,731	2,703	2,834		2,834	169.60		152,440		25,853.6	1,828,13
17	17.60	3,060	2,586	2,698	2,781		2,781	166.43			143,900	23,948.7	1,693,44
18	17.00	2,492	2,537	2,971	2,667		2,667	159.60		131,300		20,956.0	1,481,85

Missouri River sediment observations, Saint Charles, Mo.—Continued.

Date.	Gauge-reading above Saint Louis directrix.	Sediment in milligrams per pint.						Mean sediment (in grams, per cubic foot).		Discharge (in cubic feet per second).		Total sediment—	
		Horizontal combination.				Vertical combination, mean.	Resulting mean.						
		Surface.	Mid-depth.	Foot from bottom.	Mean.			Observed.	Interpolated.	Observed.	Interpolated.	Per second in kilograms.	Per day in cubic yards.
1879.													
July 19	16.77	2667	2233	2025	2308		2308	138.12		128,400		17,734.6	1,254,036
20	16.66								131.20		128,200	16,822.4	1,189,533
21	16.47	2145	1948	1846	1980		1980	118.49		127,850		15,149.0	1,071,209
22	16.32	1947	1685	1601	1745		1745	104.42		126,020		13,160.0	930,560
23	15.99								103.50		12[illegible],200	12,544.2	887,015
24	16.63	1936	1584	1604	1708		1708	102.21		127,810		13,063.9	923,770
25	17.07	1897	1553	1646	1699		1699	101.67		131,250		13,344.8	943,630
26	17.65	1884	1548	1548	1660		1660	99.34		142,660		14,171.8	1,002,109
27	18.13								96.90		152,500	14,777.3	1,044,917
28	17.07	1436	1293	1472	1400		1400	83.78		133,300		11,168.1	789,713
29	16.36	1523	1402	1371	1432	1335	1383	82.76		121,490		10,055.0	711,001
30	16.25	1176	1123	1430	1243	1331	1287	77.02		114,960		8,854.1	626,085
31	15.94	1345	1175	1156	1225	1374	1299	77.74		113,720		8,840.2	625,105
Aug. 1	15.77	1395	1223	1270	1296	1348	1322	79.11		110,330		8,728.6	617,213
2	15.61	1429	1207	1253	1296	1344	1320	78.99		107,750		8,511.6	601,866
3	15.76								78.30		108,500	8,495.6	600,730
4	15.88	1376		1163	1269	1337	1303	77.98		109,330		8,525.2	602,830
5	15.79	1107	1174	1138	1140	1312	1226	73.37		112,230		8,234.3	582,259
6	16.13	1306	1196	1190	1231		1231	73.67		124,210		9,150.3	647,030
7	16.25	1346	1180	1140	1222		1222	73.13		130,310		9,529.6	673,850
8	15.83	1401	1295	1299	1332		1332	79.71		116,920		9,319.9	659,023
9	15.23	1472	1290	1271	1344	1292	1318	78.87		108,370		8,547.6	604,410
10	14.80								75.40		101,500	7,653.1	541,160
11	14.44	1329	1155	1125	1203	1231	1217	72.83		96,350		7,017.2	496,193
12	13.89	1376	1150	1157	1228	1196	1212	72.53		96,240		6,980.3	493,585
13	13.57								71.20		89,400	6,365.3	450,097
14	13.39								70.40	84,830		5,972.0	422,290
15	12.98								69.00		81,000	5,589.0	395,205
16	12.65								67.40	77,740		5,239.7	370,504
17	12.34								66.30		72,100	4,780.2	338,016
18	12.05	1107	1003	1082	1064	1117	1090	65.23		67,430		4,398.5	311,020
19	11.77	1234	1063	1531	1276	1120	1198	71.69		68,780		4,931.0	348,680
20	11.62	1385	1300	1325	1337	1329	1333	79.77		67,430		5,379.0	380,358
21	11.41	1424	1355	1291	1357	1367	1362	81.51		66,130		5,390.1	381,142
22	11.22	1404	1302	1413	1373	1277	1325	79.29		61,420		4,870.2	344,376
23	11.02	1607	1504	1576	1562	1498	1530	91.56		62,920		5,761.0	407,369
24	10.57								88.90		57,100	5,076.2	358,944
25	10.52								88.60		56,600	5,014.8	354,600
26	10.37	1545	1354	1504	1468	1467	1467	87.79		54,450		4,780.2	338,015
27	10.23		1080		1080	1288	1184	70.85		56,240		3,984.9	281,776
28	10.00	1008	1113	1092	1071	1153	1112	66.55		55,070		3,664.7	259,140
29	9.91	913	1113	1120	1049	1089	1069	63.97		53,240		3,405.9	240,837
30	9.78	861			864	1010	937	56.07		51,590		2,892.9	204,557
31	9.48								47.50		48,500	2,303.8	162,900
Sept. 1	9.40	596	7-5	800	707	808	757	45.30			47,500	2,151.8	152,159
2	9.25	636			636	840	738	44.16		45,600		2,013.9	142,406
3	9.10	635		711	673	818	745	44.58		45,850		2,044.1	141,546
4	8.98	625	710		672	827	749	44.82		43,780		1,962.3	138,760
5	8.81	610	629	712	650	729	689	41.23		42,150		1,737.9	122,891
6	8.70	555	613	636	601	705	653	39.08		42,410		1,657.3	117,190
7	8.65								38.30		41,700	1,597.1	112,934
8	8.47	504	571	574	550	639	594	35.55		39,220		1,8[illegible]4.1	98,582
9	8.33	481	526	590	532	591	561	33.57		39,360		1,321.4	93,437
10	8.23	483	541	591	538	594	566	33.87		40,540		1,373.2	97,099
11	5.13	525	572	611	569	624	596	35.67		41,520		1,480.9	104,716
12	8.88	610	633	699	647	687	567	33.93		46,070		1,563.2	110,534
13	8.70	565	602	611	693	665	629	37.64		42,690		1,606.9	113,628
14	8.55								37.70		42,800	1,613.5	114,097
15	8.47								37.80	42,960		1,623.9	114,827
16	8.47	556	630	620	602	662	632	37.82		42,430		1,604.7	113,473
17	8.65	531	581	595	569	612	590	35.31		44,890		1,585.0	112,076
18	8.56	513	531	596	547	490	518	31.00		39,890		1,236.6	87,438
19	8.33	475	498	520	498	542	520	31.12		39,670		1,234.5	87,292
20	8.01	461	500	518	493	563	528	31.60		36,090		1,140.4	80,639
21	7.67								28.70		34,600	993.0	70,218
22	7.41	380	435	477	431	469	450	26.32		33,370		878.2	62,099
23	7.38	383	400	360	381	423	402	24.06		33,680		810.2	57,293
24	7.33								24.00	32,340		776.2	54,883
25	7.23								24.00	32,620		782.8	55,858
26	7.10	354	388	449	397	402	400	23.94		33,200		794.7	56,197

Missouri River sediment observations, Saint Charles, Mo.—Continued.

Date.	Gauge-reading above Saint Louis directrix.	Sediment in milligrams per pint. Horizontal combination. Surface.	Mid-depth.	Foot from bottom.	Mean.	Vertical combination, mean.	Resulting mean.	Mean sediment (in grams, per cubic foot). Observed.	Interpolated.	Discharge (in cubic feet per second). Observed.	Interpolated.	Total sediment— Per second in kilograms.	Per day in cubic yards.
1879.	*Feet.*												
Sept. 27	6.99	335	388	403	375	418	396	23.70	....	30,590	....	734.9	51,3[illegible]
28	6.97	....	....	....	....	....	....	....	23.60	....	30,200	712.7	50,3[illegible]
29	6.81	322	356	387	355	343	349	20.88	....	28,050	....	585.8	41.4[illegible]
30	6.84	325	353	156	278	355	316	18.91	....	30,250	....	570.1	40.4[illegible]
Oct. 1	6.74	311	317	375	334	314	324	19.39	....	....	29,500	572.0	41.3[illegible]
2	6.61	303	342	320	322	343	332	19.87	....	28,690	....	570.0	40.3[illegible]
3	6.79	293	319	203	272	330	301	18.01	....	29,010	....	522.6	36.[illegible]
4	7.03	314	344	347	335	358	346	20.71	....	30,030	....	621.8	43.9[illegible]
5	6.84	....	....	....	....	....	....	....	19.90	....	30,000	597.0	42.2[illegible]
6	6.71	281	312	330	308	336	322	19.27	....	29,920	....	576.6	40.7[illegible]
7	6.84	281	308	341	310	337	323	19.33	....	29,600	....	572.1	40.4[illegible]
8	6.77	264	286	287	279	296	287	17.[illegible]	....	30,450	....	523.0	36.9[illegible]
9	6.67	254	290	341	295	310	302	18.07	....	28,580	....	516.5	36.5[illegible]
10	6.58	252	302	320	291	332	311	18.61	....	27,820	....	517.8	36.6[illegible]
11	6.53	261	288	301	283	300	291	17.41	....	28,330	....	493.4	34.8[illegible]
12	6.77	....	....	....	....	....	....	....	22.20	....	29,800	661.6	46.7[illegible]
13	6.79	340	362	403	368	387	377	22.56	....	29,960	....	675.9	47.7[illegible]
14	6.94	256	322	308	295	319	307	17.95	....	31,160	....	559.4	39.5[illegible]
15	6.89	351	281	303	312	241	276	16.52	....	32,600	....	538.5	38.0[illegible]
16	6.84	261	280	398	313	246	279	16.70	....	30,490	....	509.0	35.9[illegible]
17	6.74	255	267	319	280	267	273	16.34	....	29,800	....	486.8	34.4[illegible]
18	6.57	210	238	528	325	277	301	18.01	....	27,950	....	503.4	35.6[illegible]
19	6.35	....	....	....	....	....	....	....	18.00	....	26,500	477.0	33.7[illegible]
20	6.57	224	256	344	275	328	301	18.01	....	29,240	....	526.7	37,2[illegible]
21	6.57	213	262	306	260	301	280	16.76	....	31,350	....	525.3	37,1[illegible]
22	6.79	261	337	378	325	336	330	19.76	....	31,490	....	622.2	43.9[illegible]
23	7.03	290	335	387	337	359	348	20.83	....	33,400	....	695.6	49,1[illegible]
24	7.23	294	342	370	335	372	353	21.12	....	33,540	....	708.5	50,1[illegible]
25	7.13	280	370	....	325	392	358	21.42	....	34,190	....	732.5	51,7[illegible]
26	6.89	....	....	....	....	....	....	....	21.20	....	32,000	678.4	47,9[illegible]
27	6.68	276	317	368	320	385	352	21.02	....	30,110	....	632.8	44,7[illegible]
28	6.48	246	284	341	290	344	317	18.97	....	27,010	....	512.4	36,2[illegible]
29	6.32	272	297	308	292	329	310	18.55	....	....	26,200	486.1	34,5[illegible]
30	6.25	....	....	....	....	....	....	....	18.30	....	25,800	472.1	33,3[illegible]
31	6.22	....	....	....	....	....	....	....	18.20	....	25,500	464.1	32,8[illegible]

APPENDIX B.

ANNUAL REPORT OF PRESIDENT MISSOURI RIVER COMMISSION, 1886–'87.

MISSOURI RIVER COMMISSION,
Saint Louis, Mo., August 2, 1887.

GENTLEMEN: Work under the construction department of this Commission during the past fiscal year has embraced repair, construction, and care of plant and construction of revetment at Saint Joseph, Mo., and construction of revetment and dike work at Kansas City, Mo. At the beginning of the fiscal year this work was in charge of Maj. W. E. Livermore, Corps of Engineers, U. S. Army, with station at Kansas City, Mo. On November 7 Major Livermore was relieved, and I was instructed by the Commission to take charge of this department of their work. Under Major Livermore's direction the greater portion of the plant had been repaired and launched, and everything got in readiness for resuming work, but the very late date, October 28, 1887, at which the allotments of the Commission received the approval of the honorable Secretary of War rendered it impossible to carry on work to advantage so late in the season. Orders were therefore given to lay the plant up for the winter, and this work was completed early in December.

As soon as danger from ice was over such portions of the plant as were needed were repaired and launched, and the tow-boats *Stone* and *Alert* sent up from Bushberg, where they had been wintered. The *Alert* was purchased for the use of the Commission December 20, 1886, at a cost of $20,000. She had been chartered the previous season and had been found well suited to the work.

KANSAS CITY, MISSOURI.

Work in this neighborhood has been throughout the year in charge of Assistant S. H. Yonge. Repairs to plant were completed May 1. On April 2, work was begun on a dike across the head of the slough above the East Bottoms. The changes in the river near Pest Island had thrown a considerable current into this slough, and it was enlarging so fast as to render it problematical whether the head of the East Bottom revetment could be held. It was therefore decided to throw a dike across the head of the slough to connect with the tow-head, thus deflecting the current from the slough with the expectation that it would eventually silt up. The dike consisted essentially of two rows of braced piles, reduced to one row on the bar near the tow-head. A foot mat 20 feet wide and 18 inches thick, is sunk around the piles to prevent scour, and a mattress 35 feet wide suspended from the up-stream side of the piles, and further supported by poles, completes the system.

The whole length of dike is 1,958 feet. It was finished June 8, but the stage of water since has been too high to determine as yet what its effect will be. The crest of dike was kept down to an elevation of about 5 feet above low water to enable drift, etc., to pass over it during floods.

The revetment of the East Bottoms was begun April 25, a second mattress party being started May 10. At the close of the fiscal year work was temporarily suspended, owing to high water. The mattress work was then complete for 5,500 feet, and complete, except on the upper bank for 635 feet. About one-fourth of the upper bank mattress was covered with stone. There remains 3,500 feet to construct to complete the work.

The details of this work are entirely similar to that done at Quindaro Bend in 1885. From A to B, 1,100 feet (see map), the mattress extends to the top of the bank and averages 88 feet in width, thence to C, 3,400 feet, the average width is 127 feet. From C to D the width is 105 feet, and for the remainder of the distance, 635 feet, only the under water mat, 88 feet wide, is constructed.

The work done in former years remains intact. On the Kaw Bend work about 500 feet of the upper bank protection was damaged apparently by water seeping back to the river from the bottom lands. This was repaired at small cost.

Both brush and stone for the work have been procured by hired labor. Much difficulty has been experienced in all departments of the work from the great scarcity and high price of common labor. The cost of all work has been greatly enhanced thereby

As soon as the river recedes to a sufficiently low stage work will be resumed on the East Bottoms revetment and pushed to completion. There will still remain a considerable fund unexpended, and the question will be where it can best be applied. It has been preliminarily decided by the Commission to commence work in Sharp's Bend, the next in sequence to the East Bottoms. The funds available will not, however, be sufficient to complete the work needed in this bend, and for other reasons I think the money can be more advantageously expended elsewhere. At the time the first work in this vicinity was projected by the Commission it was thought that the protection of Parkville Bend would ultimately be needed to prevent the Kaw Bend work from being taken in reverse. Subsequent surveys, however, showed that the protection should be extended st . further up-stream so as to include Little Platte Bend. This work was not, however, looked on as of pressing importance. During the last two years, however, there has been much caving in Little Platte Bend, where the situation now seems dangerous and a cut-off threatened. As this would be likely to make extensive changes and greatly jeopardize the work in Kaw Bend I have to recommend to the Commission that the revetment of this bend be undertaken at once and that the work in Sharp's Bend be left till another appropriation is available.

For details of work, see report of Assistant Samuel H. Yonge, Appendix B 1.

SAINT JOSEPH, MISSOURI.

The plant at this point was re-enforced from Kansas City to enable the work to be pushed more rapidly. Work began April 25, on the extension down-stream of the Bon-Ton revetment. By June 17 this work had been completed for 4,158 feet, when the near exhaustion of the allotment compelled its suspension, leaving about 2,000 feet to be done hereafter. The details of work were the same as in 1885, except that portions of the cable-system were doubled to secure a better bond with the brush. The average width of mattress was 125 feet, extending to the top of the bank. Much trouble was experienced with the bank, which is largely composed of sand and very easily eroded. This has added greatly to the labor and expense and retarded progress. The same trouble in regard to labor was experienced as at Kansas City. During the balance of the season the covering of the upper bank with stone will be completed and 3,000 cubic yards of stone will be placed on the Elwood revetment at certain exposed points.

All the work of previous years is in excellent condition.

During the month of July all work contemplated here will probably be finished, and the fleet hauled out for the winter. The tow-boat *Alert* and fifteen barges will be sent to Kansas City.

This work will about exhaust the current allotment, and in order to care for the plant and provide for contingencies it is recommended that $10,000 be transferred to this work from the Kansas City allotment.

For details of work, see report of Assistant S. W. Fox, Appendix B 2.

CONSTRUCTION OF BARGES.

On February 8, arrangements were made for the construction of fifteen barges for the work, ten to be built at Cincinnati, Ohio, by the Cincinnati Dry Dock Company, and five to be built at Levanna, Ohio, by the Boyd Manufacturing Company. At the end of the fiscal year eleven barges had been completed and accepted, and the balance will probably be delivered during the month of July, 1887.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Lieut. Col. of Engineers,
President Missouri River Commission.

The MISSOURI RIVER COMMISSION.

APPENDIX B 1.

REPORT OF MR. SAMUEL H. YONGE, ASSISTANT ENGINEER.

KANSAS CITY, MO., *July* 22, 1887.

COLONEL: I have the honor to submit the following report of operations conducted on the work of improving Missouri River in the vicinity of Kansas City, Mo., from November 7, 1886, to June 30, 1887, viz:

REPAIRS TO AND CARE OF PLANT.

The work of repairing the launching-ways at Quindaro, Kans., and extending them so as to accommodate the increased number of boats to be wintered there, was commenced November 8 and completed November 30, 1886.

The work of pulling the boats out of the river and storing them on the ways was begun November 14 and completed December 6, 1886.

As the method of doing this work was essentially the same as that employed in 1885, which was fully described in my last annual report to you, no description is thought necessary.

The fleet taken out of the river and laid up on the ways consisted of 5 hydraulic graders, 2 hydraulic pile-sinkers, 2 hydraulic pile-sinker tenders, 4 double-deck quarter-boats, 6 mattress-boats, 1 machine-boat, 29 100-foot barges, 1 64-foot barge, 3 miscellaneous hulls, 1 steamer—*Melusina*—or a total of 54 hulls.

The cost of this work, including proportionate amount of cost of administration, miscellaneous expenses, and services of steamer *Melusina* amounted to $3,530.22.

On the completion of this work, the force in the field, with the exception of a few men to watch and take care of the property, was discharged.

In the early part of February, 1887, the repairs to such boats as had not been repaired, or only partly so, during the preceding summer and fall, were begun. These consisted in recalking 38 hulls and repainting the whole fleet of 77 boats, which were all launched by May 1, 1887.

The whole cost of repairing and launching the fleet, including proportionate cost of administration, miscellaneous expenses, and services of steamer *Melusina* amounted to $6,536.64.

The fleet was subsequently removed below the Kansas City Bridge, such boats as were not immediately needed being tied up at Harlem, Mo., in charge of watchmen.

CONSTRUCTION OF WORKS OF IMPROVEMENT.

The works of improvement constructed at East Bottoms, below Kansas City, Mo., consisted of a dike and a revetment, commencing about three-fourths of a mile below the dike.

report of
t. Engr.
d 1887.

R. Suter,
U.S. Army.
Commission.

ion to the works in the East Bottoms, some repairs were made to the revet- 385 in Kaw Bend.

DIKE AT EAST BOTTOMS.

roject of December 20, 1886, for the East Bottoms revetment, it was proposed the head of the revetment by pile and mattress dikes *v-x* and *x-y* (see map), ed across a slough between a tow-head and the right bank.

he execution of this project could be commenced the depth of water in the . the line of the dikes proposed in the project had increased from 3 feet to 15 h rendered it inadvisable, if not altogether impracticable, to construct the riginally proposed, and it was determined, with your approval, to try to close h, which now had become a chute, at its head by a pile and mattress dike, expectation that this would either render the construction of the dikes origin-osed unnecessary, or would make their construction feasible by causing the shoal up.

on the dike was begun April 27, 1887. The dike was constructed in the follow-ner, viz:

the chute, from N to O (see map), a distance of 1,058 feet, two rows of piles k, while across the bar, at the upper end of the tow-head, from O to P, a dis- 900 feet, a single row of piles was driven.

eight of the dike is such that during an ordinary summer flood it will be cov-h water to a depth of from 3 to 4 feet, thus permitting ordinary drift-wood to r it without lodging.

listances between piles on the line of the dike are about 11 feet each; that 1 the rows 10½ feet.

iles placed in the water on the line N-O were sunk by the use of a water jet, tration being from 12 to 28 feet; those on the bar were driven by an ordinary -driver to a penetration of from 12 to 14 feet. The depth of water during the sinking varied from 4 to 11 feet.

iles were braced longitudinally by walings, 4 by 8 inches, drift-bolted to them, rows of piles by diagonal braces, 4 by 6 inches, bolted and lashed by wire cable eads of the piles, the piles opposite each other being also tied together by 4 by 6 nbers.

t mattress, 20 feet wide by about 16 inches thick, projecting 4 to 5 feet above and e rows of piling, was placed on the bottom of the river and on the dry bar to the piles from scour. The foot mattress from N to O was made in sections from 00 feet long, by laying fascines of brush on a frame of light timbers, suspended the construction of the mattress by wires from the tops of the piles, after which as placed on top of the brush a top frame, similar to the bottom frame, and the nd together by wire lashings. The suspending wires were then cut and the mat-nk. The foot mattress on the bar was of the same construction as that placed in er.

ont of the double row of piles, on the up-stream side, was placed a continuous mattress, constructed from ways erected on a small barge, 30 to 35 feet wide, oth of its edges selvaged and strengthened by four longitudinal ⅜-inch steel wire In weaving the mattress cypress poles 25 to 30 feet long, 6 inches in diameter point, and from 10 to 12 inches at the butt, lashed by wire cable to the head of lternate pile of the up-stream row, were placed under the mattress and lashed nd to the strengthening wire cables, in order to prevent the mattress from being against the piling by the current. The mattress was sunk by the force of the t, after which stone was placed on its up-stream edge.

roved extremely difficult to keep this mattress afloat, after getting 600 feet from ore end of the dike, on account of its presenting an almost solid surface to the t, the meshes of the weaving being choked by hay and straw refuse floating in the Finally the mattress could only be kept afloat by supporting it every 20 feet by resting at one end on the dike and at the other on a barge.

three occasions, to prevent its being carried under the mattress boat or its being up by the current, the mattress had to be dropped from the boat and allowed to after the ends had been selvaged, in which cases it became necessary to start new ons, which were made to overlap the sections already sunk.

e woven mattress, which was 1,060 feet long, was completed June 8, 1887.

June 11, 1887, the river had risen so as to cover the dike and it has remained un-ater ever since. Its effect so far has been to cause a fill above about even with the f the structure, while immediately below there is a slight deepening.

ere is practically no change in the shape of the cross-section of the chute at its r end, but if the dike is not destroyed I have no doubt that the desired purpose

of causing the chute to silt up will be attained. The only cause of apprehen sists in the fact that a flat-boat, which was turned adrift by one of the sand nies at this point, lodged against the dike before its completion and partly su which the foreman in charge of the dike party filled it with stone and sunk pletely. This was done without my knowledge and I was not informed of th rence until it was too late to get the barge out without great loss of valuable ti

Hydraulic pile sinker No. 8 was used in the jet pile sinking. As no descri this apparatus has been published, the following is given, viz:

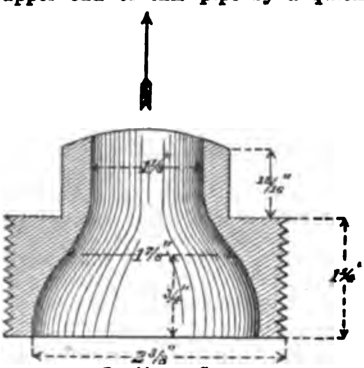
It consists of two barges, the main boat, 75 feet long by 18 feet 10 inches w feet deep, on which are mounted a boiler, steam-pump, Providence steam capst hand deck pump, and the cross boat, 37 feet 8 inches long by 18 feet 10 inches 3 feet deep, which carries a steam windlass with two drums, one for rapid and t for slow speed, a hoisting derrick, and a pile platform, 19 by 19 feet, 12 feet ab deck, supported by posts, at one end of the boat. The two barges are held rig gether by two ratchet coupling hooks.

The steam for running the windlass is carried below deck, except at the point the two barges are in contact, where it is carried from one boat to the other by rangement of pipe and ells, with a universal joint which allows some motion in th without bringing strain on the pipe.

The steam-pump is a Worthington duplex, with water cylinders, 7 by 12 inche steam cylinder 10 by 12 inches.

The boiler is of the locomotive type, with 54 tubes 3 inches in diameter by 9 inches long, and furnishes an abundance of steam to do the work without forcin

The water connections between the pump and the nozzle were as follows. feet 4½ inches of 4-inch wrought-iron pipe, laid horizontally on the deck main boat; a 25-foot section of 4-inch rubber hose attached to the pipe; 2 4-inch pipe, leading from this hose to the platform on the cross boat; attach upper end of this pipe by a quick coupling, a 25-foot section of 2½-in hose, wrapped with tarred marlin; and a 2 wrought pipe, coupled up in three sectio feet 7 inches long over all, to the lower e which is attached the cast-iron nozzle-tip, 1⅛ inches bore, whose dimensions and shap shown on the accompanying sketch.



Section of Jet Pile Sinker Nozzle

In operating the pile sinker it was inte that the steam windlass which was used for h ing the piles and for pulling up the 2-foot pipe after the pile had been sunk should supply the power necessary to force the pile d which was applied to the head of the pile means of a 4-inch manilla rope, but as it out of order several times at the beginning of work, the steam capstan was used for this p pose, and worked so satisfactorily that its was continued till the pile sinking was c pleted. The strain thus applied was estim to vary from 3,000 to 5,000 pounds. The 2-i pipe was attached to the piles by two 2½ by 5 inch staples, one placed above the other below the couplings connecting the sections of which this pipe was m up. This arrangement worked satisfactorily, the pipe being quickly attached to t pile and easily removed by applying a strain on the pulling-up line. The jet-pipe e tended 6 inches below the foot of the pile.

The water pressure at the pump was usually 100 pounds, steam pressure 80 pound speed of pump 45 strokes per minute.

The following table contains the data collected relating to the pile sinking, the "ca culated nozzle pressure" being obtained by deducting from the pump pressure the prop amount for loss of pressure due to friction in pipes and hose between the pump and th nozzle.

The "discharge per minute for calculated nozzle pressure" was taken from standar tables.

	Time worked by crew in sinking piles.	Piles sunk.	Total penetration.	Average penetration.	Maximum penetration.	Calculated nozzle pressure.	Discharge per minute for calculated nozzle pressure.	Remarks.
	Hours.	*Number.*	*Feet.*	*Feet.*	*Feet.*	*Pounds*	*Gallons.*	
[illegible]	2	2	44	22.0	22	65	250	Experimenting.
[illegible]	5	5	87	17.4	18	65	250	Do.
[illegible]	10	9	154	17.1	20	65	250	
[illegible]	9	11	217	19.7	27	72½	264	
[illegible]	10	20	446	22.3	26	72½	264	
[illegible]	6	14	302	21.6	26	77	271	Working through strata of hardpan.
4	8	18	390	21.7	24	80	277	Do.
5	7	14	307	22.0	25	77	271	Crew used in lightening pile-barge which was aground three hours.
6	6	10	226	22.6	26	77	271	Pump out of order four hours.
7	8	13	281	21.6	26	72½	264	Shoal water.
20	3	6	131	21.8	23	72½	264	Started sinking piles at 3 p. m.
21	9	14	311	22.2	28	80	277	
23	10	23	433	18.8	22	80	277	
24	10	16	291	18.2	21	81	279	
25	10	27	527	19.5	21	80	277	
[illegible]	6	15	278	18.5	19	80	277	Finished pile sinking.
[illegible]	119	217	4,425	20.39	....	....	....	

[illegible]he [illegible]lowing is a statement of the cost of the dike, showing the quantities and cost [illegible]atex ials used:

Statement of cost of dike in East Bottoms.

For what expended.	Quantity.	Price.	Amount.
MATERIALS.			
[illegible]es... ....number...	295	$1.19413	$352.27
[illegible]press poles to support woven mattress........do......	23	1.45	33.35
[illegible]umber, B. M........(price is per 1,000 feet)...	36,577	*19.889821	727.51
[illegible]nch square iron for drift-bolts........pounds...	2,394	*.026729	63.99
[illegible]rush in foot-mat........cords...	400	1.640227	656.09
[illegible]one for sinking foot-mat........cubic yards...	409	1.156	472.80
[illegible]rush in screen-mat........cords...	478	1.640227	784.03
[illegible]one for ballast on screen-mat........cubic yards...	225	1.156	260.10
[illegible]inch steel wire cable for screen mat........pounds...	1,210	.04615	55.84
[illegible]inch steel wire cable for foot-mat........do......	494	.04615	22.80
[illegible]inch steel wire cable for bracing piles........do......	964	.04615	44.49
[illegible]o. 10 wire for wiring foot-mat........do......	2,100	.056	117.60
Total cost of materials........	....	....	3,590.87
LABOR, FUEL, AND SUBSISTENCE.			
Piles sunk with jet........number...	213	2.60648	555.18
Piles driven with hammer........do	82	3.136219	257.17
Making 3,900 square feet of foot-mat........per 100 sq. feet...	....	.876282	341.75
Making 1,060 linear feet of screen mat ....per linear foot...	....	.79684	844.65
Attaching bracing to piling........	....	....	252.43
Sinking foot-mat........	....	....	151.74
Sinking screen-mat........	....	....	138.35
Total cost of labor, fuel, and subsistence........	....	....	2,541.27
Add total cost of materials........	....	....	3,590.87
Add proportionate cost of administration services of steamer *Melusina* and miscellaneous expenses........	....	....	869.25
Add proportionate cost of services of tow-boat *William Stone*........	....	....	1,121.75
Total cost of dike in East Bottoms........	....	....	8,123.14
Average cost per linear foot........	....	....	4.15

*Average.

REVETMENT AT EAST BOTTOMS.

The work in the East Bottoms is designed to constitute a link in the systematic improvement of the river, the purpose of which is to prevent any violent changes in the regimen of the river and, by making its banks permanent, to compel the river to apply its energies to deepening and contracting its channel instead of to widening it and causing it to shoal up.

The bank in the East Bottoms has been cutting away for several years. The average width of the erosion since 1878, about which time this action probably began, amounts to 832 feet over a length of 9,340 feet, making a total area of about 178 acres.

In the fall of 1883, four rock and pile spur dikes were constructed by private parties to protect their lands in the upper part of East Bottoms from the encroachments of the river, and were flanked, within eighteen months after they were constructed, by the action of the eddies which they produced, and are now buried in the sand on the other side of the river.

The length of the bank to be protected in the East Bottoms is 9,500 feet, from A to F (see map). From A to B, a distance of 1,100 feet, the bank is slightly above overflow and consists of gumbo, which erodes slowly; from B to C, a distance 3,400 feet, the bank is about 7 feet above ordinary floods, and is composed of very fine sand, which washes rapidly when at all exposed to wave or current action; from C to D, a distance of about 1,000 feet, the bank varies in height from 7 feet above overflow at C to just below overflow at D. The remainder of the bank, from D to F, is under water every summer.

The total length of the bank protected this spring amounts to 6,135 feet.

The details of the revetment and the method of its construction are the same as those adopted for the protection of Quindaro Bend in 1885, described in the report of that season's operations.

From A to B (see map) the mattress constructed extends to the top of the bank and has a total average width of 88 feet, the bank above water being graded on a slope of 1 vertical to 2½ horizontal. From B to C the mattress was carried to within 2½ feet of the top of the bank, and has a total width of 127 feet, the bank being graded to a slope of 1 vertical to 2¾ horizontal. From C to D the mattress extends to the top of the bank and has a total average width of 105 feet, the bank being graded to a slope of 1 vertical to 3 horizontal. From D to E, the top of the bank being just level with the water, no bank mattress was woven, but a mattress 84 feet wide was sunk with the intention to construct a bank mattress as soon as the summer flood subsides.

The preliminaries of organizing parties and procuring construction material were sufficiently advanced for one construction party to commence weaving mattress on April 25, a second party being put in operation on May 10.

Party No. 1 commenced mattress work at A and party No. 2, 1,500 feet below the point reached by party No. 1 at the time the former party began to work. The junction of the two sections of mattress constructed by the two parties was effected on June 10, and as at that time there were strong indications that the June rise would soon set in, and the river had reached so high a stage that no favorable point for commencing a new section of mattress could be found below the work of party No. 2, party No. 1 was disbanded.

The mattress work was carried on under the usual difficulties incident to carrying on work during a high stage of water.

The extent of mattress constructed in East Bottoms amounts to 6,790 linear feet (including laps), equal to 720,400 square feet.

The total area of upper bank mattress covered with stone amounts to 77,200 square feet, leaving an area estimated at 239,000 square feet still to be covered, when the stage of the water permits doing so. This will complete the revetment as far as the mattress has been carried.

It is expected that the stone work for all the bank mattress above water will be completed during the month of August.

The following is a statement of the cost of this work, showing the quantities and cost of materials used:

Statement of cost of East Bottoms revetment.

For what expended.	Quantity.	Price.	Amount.
MATERIALS.			
Brush in woven mattress.....cords...	5,040.5	$1.640227	$8,267.56
Brush used in repairing toe of graded bank.....do.....	100.0	1.640227	164.02
Stone.....cubic yards...	4,467.4	1.155910	5,163.91
½-inch steel cable.....pounds...	25,630.0	.046150	1,182.82
⅜-inch steel cable.....do.....	4,761.0	.053165	253.12
¼-inch steel cable.....do.....	13,664.0	.051576	704.73
Total cost of materials.....	.....	.....	15,736.16
LABOR AND SUBSISTENCE.			
Grading bank.....cubic yards...	36,752.0	.032363	*1,189.40
Square feet mattress woven.....per 100 square feet...	720,400.0	.830920	†5,985.95
Sinking mattress.....	.....	.....	325.92
Covering upper bank with stone.....per 100 square feet...	77,200.0	1.181234	911.99
Total cost of labor, subsistence, etc.....	.....	.....	8,413.26
Add total cost of materials.....	.....	.....	15,736.16
Add proportionate cost of administration, services of steamer *Melusina* and miscellaneous expenses.....	.....	.....	3,423.99
Add proportionate cost of services of tow-boat *William Stone*.....	.....	.....	4,417.72
Total cost of East Bottoms revetment to June 30, 1887.....	.....	.....	31,991.13

* Also including fuel. † Including the setting of deadmen.

The estimated cost of completing the 6,135 feet of revetment by constructing 20,000 square feet of bank mattress and covering 239,000 square feet of upper bank mattress with stone is $11,213, which would make the total cost of 6,135 feet of revetment $43,204.13, or $7.04 per linear foot.

GRADING.

In carrying on the grading of the bank, hydraulic graders Nos. 3 and 6 were employed.

Although the grading by jet was not carried any farther ahead of the mattress work than was absolutely necessary, it often happened that before the mattress party could reach the portion of the bank graded ahead the toe of the grade was washed away by the action of the current, which action was aggravated by the water from the jet. This difficulty was overcome by grading only about half-way down the bank with the jet, washing not more than one-third of the excavated material into the river, the remainder being left at the foot of the slope made by the jet, and afterwards used in completing the slope by the use of shovels, bundles of brush being often used to re-enforce the toe before being covered by the mattress.

No data of value relating to grading could be collected on account of its not being carried on continuously for any length of time.

The total quantity of material excavated amounted to 36,752 cubic yards. The total cost of excavating, including service of graders, labor of shoveling and repairing toe of grade with brush, fuel, subsistence, etc., amounted to 3.2363 cents per cubic yard.

REPAIRS TO KAW BEND REVETMENT.

About 1,600 feet above the lower end of the revetment in Upper Kaw Bend the top of the river-bank is several feet under water during spring floods. Immediately behind the top of the bank there is a depression in the ground, in which, from last spring's flood, there was left quite a quantity of water, which, having no surface outlet, and the ground being pervious, percolated through the soil and ran out through the face of the sloped bank, washing out the fine materials of which the banks are here composed. This action resulted in the portion of the mattress covering the bank being left unsupported and in its breaking down under the weight of the stone covering.

As soon as the damage was discovered, materials were gathered and a party set to work to make the necessary repairs, which were begun April 12.

These repairs consisted in regrading about 450 linear feet of bank and weaving a mattress, covering the new slope, and extending about 20 feet into the stream, overlapping the old mattress. In this work about 23,000 square feet of mattress was woven and about 9,000 square feet of bank mattress covered with rock.

To prevent a recurrence of the accident, a box drain was constructed to lead the water from the slough to the river.

The whole cost of making these repairs amounted to $967.91.

CONSTRUCTION MATERIALS.

The stone, brush, and piles used on the work this spring were all procured by hired labor.

STONE.

With a view to procuring stone by hired labor for this season's work, the bluffs of the river between Parkville, Mo., and Wayne City, Mo., were examined, and it was found that suitable quarries could be opened at Parkville, Mo.; Quindaro, Kans.; and Wayne City, Mo. As at that time it appeared doubtful as to whether it would not be difficult, if not impossible, for a steamer with a tow to pass through the Kansas City Bridge, and as the works projected for the summer's operations are located below the bridge, it was thought preferable to obtain the stone at Wayne City, Mo., which is situated about 11 miles below the Kansas City Bridge.

A party was organized and commenced preparations for quarrying on April 5.

The face of the quarry, beginning at the bottom, appears as follows, viz: 21 feet of rock; 4 feet of tough blue clay; 13½ feet of rock; 1 foot of clay; 5½ feet of rock; 6 feet of shale; 2 feet of clay, and 4 feet of surface soil.

In opening the quarry considerable expense had to be incurred in stripping, constructing a macadamized roadway from the quarry to the landing, constructing landings, etc.

The stone procured here is of excellent quality and far superior to any furnished to this work in former years, but exceedingly tough and hard to break up, and the stripping has proved difficult and expensive.

The quarry was opened so as to give a total height of rock face of about 43 feet, with a length of 150 feet. In quarrying this height of face about 2,500 cubic yards of stripping had to be removed, which consisted of hard shale, tough blue clay, and imperfect rock.

After quarrying a month the stripping by the usual means was found to be so expensive, that it was decided to try the use of a water-jet, supplied by one of the hydraulic graders for this purpose, and also for lengthening the face of the quarry, to enable a larger force to work and increase the output.

Grader No. 5 was sent to the quarry June 13, and a line of wrought-iron pipe laid from the grader at the river bank up the hill to the top ledge of rock, about 120 feet above the river, the line consisting of 130 feet of 6-inch pipe, 55 feet of 5-inch pipe, and from 300 to 400 feet of 4-inch pipe, to which was attached three 25-foot sections of 4-inch hose, with a 3-foot play-pipe, provided with a 1¼-inch smooth nozzle. As the grading-boat is sometimes exposed to waves from passing steamers, and the stage of the river at this season is continually changing, a rigid connection between the river end of the pipe-line and the pump-discharge could not be used. Therefore a hinge, permitting a limited amount of vertical and horizontal motion to the boat, without straining the pipe, and made up of short sections of 6-inch pipe with ells and nipples, was set up between the two points mentioned above, which arrangement answered the desired purpose satisfactorily.

The grader first employed for this service had just started to work, when a crack was found in one of the water-cylinders of the pump. As there was a probability of this crack extending, if the use of the pump was continued without being repaired, this grader was replaced by Grader No. 8.

On account of the river water at this season being very muddy, the grader boiler foamed after steaming several hours successively and could not furnish the necessary steam pressure without forcing the fires. The boiler of Grader No. 3 was, therefore, coupled up with that of Grader No. 8.

The pump on Grader No. 3, manufactured by Gordon & Maxwell, is a duplex, fly-wheel, with compound steam cylinders, water cylinders 10 inches in diameter by 12 inches stroke, and has a capacity of about 425 gallons per minute at the speed at which it was run at the quarry; that is, 26 to 27 revolutions per minute.

In order to give the necessary nozzle pressure of 100 pounds, a pump pressure of 180 pounds was required. The nozzle pressure, taken at the base of the play-pipe, varied from 90 to 115 pounds, but was usually 100 pounds.

The stripping by the jet up to June 30 amounted to 1,200 cubic yards excavated from the top of the top ledge, one-half being shale from ½ inch to 4 inches thick, one-eighth tough clay, and three-eighths surface soil, full of rock and roots.

While the lighter portion of this material was carried off to the river, the tough and heavier portions lodged partly in the quarry-yard and partly on the lower ledges of rock, the latter part being also afterwards washed down into the yard by the use of the jet.

The excavated material in the quarry-yard, amounting to 2,500 cubic yards, lies in front of the lowest ledge of rock, and consists of a mixture of shale, loose rock, and clay, compacted by the water, and will have to be removed by the use of wheelbarrows, carts, or some other means, as it has been found impracticable to do this by the use of the jet on account of the yard not having sufficient slope for that purpose.

The following table contains the data of the six days during which this grader was employed prior to the close of the fiscal year:

Date.	Actual time running pump.	Average nozzle pressure for whole time.	Average discharge for average nozzle pressure (Ellis fire streams) per hour.	Water used to move 1 cubic yard of material.	Material moved per hour.
1887.	*Hs. M.*	*Pounds.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards*
June 25	5 01	99½	91.73	2.706	33.90
June 26	6 05	102	92.75	2.090	44.38
June 27	6 45	101	92.57	2.083	44.44
June 28	4 21	99	91.43	3.060	29.88
June 29	8 23	96	90.07	3.775	23.86
June 30	7 41	97	90.58	3.763	24.07

The net cost of this stripping, including the labor and subsistence of the grading crew, fuel, etc., but exclusive of laying up the pipe line and other preparations, amounts to 11½ cents per cubic yard.

There still remained, on June 30, between three and four weeks' work for the grader at the quarry, in which time it is expected to do all the stripping that can be done by the grader for the present. When this work is completed the quarry will have a face of about 340 feet in length, which, it is estimated, will produce about 33,000 cubic yards of stone.

On completing the work by the graders, two steam-drills will be put to work, the boilers for which have been set up on top of the bluff back of the quarry face.

As it was feared that the use of the muddy river water would injure the steam drills, a pond to hold a two months' supply of water has been dug on top of the bluff behind the boilers, and has been filled by the grader.

After these preparations are completed and several minor changes made, it is expected to reduce the cost of procuring stone materially. The total quantity of stone quarried amounts to 6,000 cubic yards, the cost of which, including labor, subsistence, explosives, cost of quarry privileges, and proportionate cost of stripping, is $1.15½ per cubic yard.

Quarrying was suspended on June 27, the immediate needs of the revetment in East Bottoms having been supplied, and the procuring of stone, while the stripping by the grader was going on, having become difficult on account of the amount of water in the quarry yard.

BRUSH.

A party was sent out to procure brush and piles on April 12 and a second party on May 2.

The total quantity of brush procured amounted to 6,023½ cords, nearly all of which had to be transported a distance of 14 miles up-stream.

The average cost of brush loaded on barges, including the cost of 10 cents per cord on on the stump, labor, subsistence, and wire for bundling, but not the cost of transportation by tow-boat, amounted to $1.64227 per cord.

The average cost of brush per cord this season is about 4½ per cent. higher than it was in 1885, which is probably owing to the instability of the labor employed this season, which has had the effect of increasing the expense of the work, either directly or indirectly, in all its branches.

From an inspection of the brush patches from which the brush for the work of 1885 was obtained, it appears that but a small quantity can be gotten from them for the work to be done this season. This material is now becoming very scarce within easy towing

distance of the work, and in carrying on operations this summer and fall most of the brush will have to be brought a distance by river of over 100 miles.

If the present system of revetment is to continue to be used for several years, steps will have to be taken to preserve the present brush patches, as otherwise the brush will gradually disappear through depredations of roaming cattle, fires, the growth of cotton-wood, overflows, and the ground being put into cultivation.

It will probably prove a measure of economy, if not one of absolute necessity, to start and maintain willow plantations to supply this material to work to be done in the future.

CHANGES IN THE RIVER.

The recent survey of the river from the head of Little Platte Bend to the lower end of Sharp's Bend shows that the erosion which has taken place in the different bends is as shown in the following table, viz:

Locality.	Length of bank eroded.	Average width of erosion.	Area of erosion.	Right or left bank.	Period of erosion.	
					From—	To—
	Feet.	*Feet.*	*Acres.*		1886.	18[illegible]
Little Platte Bend	7,680	460	81	Right	April	June
Parkville Bend	9,050	68	14.1	Left	April	June
Quindaro Bend*	None	None	None	Right	August	June
Upper Kaw Bend*	None	None	None	Left	August	June
Lower Kaw Bend†	Slight erosion.			Left	August	June
Pest Island			25		February	June
Sandbar around Pest Island‡			160		April	June
Bank in front of Harlem, Mo	8,560	71	13.9	Left	August	June
East Bottoms	7,270	95.5	15.9	Right	August	June
Sharp's Bend	10,800	201	49.8	Left	August	June

* Protected by revetment.
† Slight erosion in part unprotected by revetment.
‡ Including 1,200 feet above north end of bridge.

It will be seen from the above table that the erosion in Little Platte Bend has been very extensive and unless steps are taken to prevent its continuance there is danger that through the wearing away of the peninsula at the foot of Little Platte Bend the left bank of Parkville Bend will be exposed to the direct impact of the stream and consequent erosion, which would probably result in such changes in the regimen of the river as would make the revetment at Quindaro, if not also that at Kaw Bend, useless.

The most remarkable and extensive change on the reach is the washing away of Pest Island, embracing about 25 acres of land, slightly above ordinary overflow. In February, 1886, as has been described in the report for that year, the gorging with ice of what was then the main channel of the Missouri River, just below the mouth of the Kansas River, resulted in the formation of an additional channel north of Pest Island, the two channels uniting below the Kansas City bridge. On the coming of the spring rise of 1887 the north channel began to change its course, crossing diagonally from the point opposite Wyandotte, Kans., and joining the old channel above the bridge, thereby eroding the lower end of Pest Island until the whole island was destroyed.

The final effect of this change can not be definitely determined until the high water subsides, but it is probable that the bank in front of Harlem, Mo., will now be attacked by the stream.

In conducting the operations I have been assisted in the field by Assistant R. H. Bacot in charge of plant repairs and construction work, and by Assistant A. H. Weber, in charge of surveys and construction work, and in the office by Mr. E. F. Hermanns, all of which gentlemen have rendered valuable service.

I have the honor to be, very respectfully, your obedient servant,

SAM'L H. YONGE,
Division Engineer.

Lieut. Col. CHARLES R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX B 2.

REPORT OF MR. S. WATERS FOX, ASSISTANT ENGINEER.

SAINT JOSEPH, MO., *July* 18, 1887.

COLONEL: I have the honor to submit the following report of the operations under my charge on the Saint Joseph division of Missouri River during the fiscal year ended June 30, 1887:

In accordance with your instructions of June 14, 1886, I submitted to you under date of July 16, 1886, a report of the operations under my charge from July 1, 1885, to May 31, 1886.

From the latter date until November 5, 1886, the period during which operations were conducted under the direction of Maj. W. R. Livermore, Corps of Engineers, U. S. Army, the work was confined to the usual office duties, repairs, and care of plant, viz:

Under instructions from Major Livermore, received August 11, the following pieces were thoroughly repaired and launched, viz: Steamers *Sabrina*, *Thetis*, and *Doris*, Quarter-boats Nos. 1 and 5; 9 barges, 25 by 100 feet; 8 barges, 16 by 64 feet; 1 mattress-boat, and 1 derrick-barge.

Under instructions of November 5 the entire fleet was pulled out of the river, with the exception of two old hulls that were worthless. The latter were subsequently sunk by floating ice.

SPECIAL SURVEY.

In accordance with instructions, dated December 11, 1886, a survey was made of the river from the bridge at Saint Joseph to the head of McQueen's Bend. With the exception of two triangulation stations at the eastern and western approaches to the bridge, none of the points of the 1882 survey could be found. It was therefore necessary to establish a chain of blank triangles from the bridge to Geary City. Field work was completed December 29, 1886. A report of the survey and a map to a scale of 1″=2,000′, showing also the shore-lines as surveyed in 1882, was submitted under date February 12, 1887, with a project and estimates of cost of construction of works not previously projected and deemed necessary to complete the improvement of the river in the vicinity of Saint Joseph.

Under date of February 10, 1887, I submitted a project with estimates of cost and quantities of material required for the expenditure of $50,000—the balance then available for field work on the Saint Joseph division. This project, which was approved, contemplated the extension of the Bon Ton revetment 6,000 feet down-stream, and the distribution of 3,000 cubic yards of broken rock on the Elwood revetment. Both of these works were included in the original project.

Complying with the instructions contained in your letter, dated March 11, 1887, the following pieces were repaired and launched, viz: 2 quarter-boats, Nos. 1 and 5; 9 barges, 25 by 100 feet; 8 barges, 16 by 64 feet.

This fleet was increased by the following pieces, transferred from the Kansas City division, and delivered in two tows by the U. S. Steamer *Alert;* the latter being also assigned to this work for service during the active season, viz: 1 hydraulic grader No. 7; 2 mattress boats; 6 barges, 25 by 100 feet.

One of the 25 by 100 feet barges was converted into a quarter-boat for the use of the brush party during the season by the erection on it of a light temporary cabin. The steamer *Alert* arrived with its first tow April 14, and with its second on April 25.

BRUSH.

Brush cutting began April 14, and was continued without interruption, except on account of rain, until finally suspended June 13; 3,628.05 cords were delivered at a cost of $1.56 per cord on barges.

The unusually large percentage of dead and worm-eaten brush found this season was probably due to the drought of last year, and is largely the cause of the increased cost of cutting.

Average haul 1.14 miles; average tow 7 miles down-stream.

ROCK.

Instructions having been received that rock would be procured by hired labor a quarry was opened April 14, and has been operated without interruption; 9,617.33 cubic yards had been delivered on barges to June 30, at a cost of $0.788 per cubic yard.

The quarry presented a face of limestone 476 feet in length, and 20 feet high.

The haul by wagons is 800 feet. The tow 10 miles down-stream.

The stripping was quite heavy and, as it was necessarily done by hand, makes a large item in the cost of the rock.

The drilling was done by hand. Various explosives were used, but the large majority of the blasts were made with Du Pont's F. F. F. black blasting powder, which seemed most effective.

HYDRAULIC GRADING.

Grading began April 23, with Hydraulic Grader No. 7, and was continued until final suspension, June 14; 4,165 lineal feet of bank were graded, involving the removal of 51,249 cubic yards of earth, at an average cost of .0248 cents per cubic yard. As far down as the Horse-shoe slough the bank was of average composition, and the cost of that portion of the work was remarkably low, being but $0.0105 per cubic yard. From the slough down, however, the material was so fine and unstable that it was only with the greatest care that a grade could be obtained and hand grading had to be resorted to frequently.

The grade would sometimes cave in for considerable distance before and after it had been completed, and even after the mattress had been laid on it. On this account and our inability to keep the two mattress parties supplied with men, one of the mattress boats was dropped on June 2. From that time on the grader was employed but a few hours each day or enough to barely keep out of the way of the mat boat. The grader was provided with a Knowles compound condensing duplex pump, the water plungers being 10 inches in diameter.

The following table shows the amount and cost of work done each day:

Cost exhibit of hydraulic grading.

Date.	Earth removed.	Water used.	Ratio water and earth.	Time pump worked.	Coal used.	Labor and subsistence.	Total cost.	Cost per cubic yard.	Length of 4-inch hose.
1887.	Cu. yds.	Cu. yds.		h. m.	Bush.				Feet.
May 2	1,176.6	1,095.03	1.07	7 42	44	$11.87	$16.82	$0.014	50
3	1,688.8	1,159.03	1.45	8 9	48	11.87	17.27	.010	75
4	1,523.8	1,151.92	1.32	8 6	44	11.87	16.82	.011	75
5	1,550.2	1,104.49	1.40	7 46	47	11.87	17.16	.011	75
6	1,458.2	1,011.11	1.44	7 34	46	11.87	17.05	.011	75
7	1,708.0	1,035.61	1.74	7 45	42	11.87	16.60	.009	75
9	1,907.2	888.62	2.14	7 21	41	11.87	16.48	.008	50
10	1,356.2	941.01	1.44	7 47	41	11.87	16.48	.012	50
11	822.2	947.05	.86	7 50	43	11.87	16.71	.020	50
12	809.1	930.93	.86	7 42	42	11.87	16.60	.020	50
13	1,792.0	1,013.55	1.76	8 23	46	11.87	17.04	.009	75
14	1,692.0	1,017.58	1.66	8 25	47	11.87	17.16	.010	75
16	1,430.3	960.48	1.48	8 2	48	11.87	17.27	.012	75
17	2,133.3	964.46	2.21	8 4	50	11.87	17.60	.008	75
18	1,600.0	912.85	1.75	7 38	46	11.87	17.04	.010	75
19	1,513.2	861.03	1.75	7 12	42	11.87	16.59	.011	75
20	1,393.7	994.57	1.40	8 19	39	11.87	16.26	.011	75
21	1,178.7	783.30	1.50	6 33	37	11.87	16.15	.013	75
22	1,829.8	1,152.02	1.58	9 4	43	12.79	17.63	.009	75
24	1,628.0	1,236.73	1.81	9 44	45	12.79	17.85	.010	75
25	1.840.2	1,040.53	1.77	8 25	46	12.79	17.96	.009	75
26	2,090.6	1,052.89	1.78	8 31	42	12.79	17.51	.008	75
27	1,248.6	762.37	1.63	6 10	30	12.79	16.17	.012	75
28	1,758.3	1,087.94	1.61	8 48	43	12.79	17.63	.010	75
June 1	1,132.4	799.95	1.41	5 15	35	12.22	16.16	.014	75
2	1,197.7	566.69	2.11	4 23	28	12.22	15.37	.012	75
3	535.1	323.21	1.65	2 30	18	12.22	14.24	.026	75
4	469.4	235.81	1.99	1 43	15	12.22	13.91	.029	75
6	732.3	467.03	1.56	3 24	27	12.22	15.26	.030	75
7	704.1	503.45	1.40	3 40	29	12.22	15.48	.022	75
8	957.6	538.01	1.78	3 55	31	12.22	15.71	.016	75
9	576.3	446.43	1.29	3 15	20	12.22	14.47	.025	75
10	510.9	565.26	.90	4 7	23	12.22	14.81	.029	75
11	588.8	528.64	1.11	3 51	27	10.54	13.58	.023	75
13	464.6	377.75	1.20	2 45	24	10.54	13.24	.028	75
14	331.8	499.00	.71	3 38	22	10.54	13.01	.039	75
	45,330.0	20,958.42	1.51	233 26	1,341	432.00	583.09	.012	......

MATTRESS.

Weaving was begun April 25, and continued until June 17, when the force was reduced to a few men necessary to do some repair work.

Four thousand six hundred and ninety-six and four-tenths lineal feet, or 586.105 square feet, of mattress were woven, protecting 4,158 linear feet of bank.

The several items of cost are shown in the cost exhibit. With your approval the cable system was modified as follows, viz:

The longitudinal system consisted of a single three-fourths inch cable in the outer selvage edge, and 7 sets of double three-eighth inch cables, spaced 5, 10, 15, 15, 15, 15, and 15 feet apart, respectively, beginning at the outer edge. The transverse system consisted of single three-fourths inch cables, spaced 50 feet apart, and sets of two three-eighths inch cables, spaced 16⅔ feet apart. One of each set of the longitudinal cables led out on the bottom of the mat, the other led to the mat from a pulley fixed about 10 feet above the upper ends of the ways; one of each set of the transverse cables was laid on top of the brush just in the rear of the weavers, the other passed entirely under the mat and directly beneath the former.

At the points where the transverse cables crossed the longitudinals the latter were pin-twisted together, then the transverse, if a three-fourths inch cable, was passed on its way ashore through the eyes thus formed; when the transverse were two three-eighths inch cables the upper one passed through the eyes on its way to the bank, and after both were made fast ashore to a deadman, the two were pin-twisted together on the stream side of each longitudinal, beginning ashore and working out to the selvage cable, to which all of the transverse cables were made fast as usual. The mattress was thus blocked out in rectangles, two of whose sides were constant, *i. e.*, 16⅔ feet, and the other sides varying from 5 feet to 15 feet. It would be next to impossible for a rent in the mat to extend beyond the limits of the block in which it was made. This was amply illustrated. During the June rise the mat which was sunk to the upper gunwale of the mattress-boat, was subjected, while being sunk, to a very swift current. The drift would occasionally force its way through at a thin spot, but in no case did the tear extend beyond the next transverse below. In previous constructions such an occurrence was a very serious matter; the rent or hole would invariably enlarge, and frequently to such an extent and so rapidly as to make it necessary to drop the mat and take a new start, lapping well above the tear. Owing to the character of the bank as mentioned above, the mattress was woven unusually thick and close in the throat, *i. e.*, from near low-water line to mid stage, and as a still further precaution against eddy or wave action, this portion of the mat was covered with small rock. On the same account the amount of rock placed on the mat will be somewhat heavier than usual, namely, about 2.4 cubic yards to the lineal foot.

In accordance with your instructions of June 13, the ways and boat-yard were repaired, and the following pieces pulled out of the river: 2 barges 16+64 feet; 2 mat-boats, Nos. 3 and 5; 1 quarter-boat, No. 1; 1 hydraulic grader, No. 7. There remain in the river July 1, Quarter-boat No. 5; 6 barges, 16+64 feet, and 15 barges 25+100 feet. Of these the 6 small barges are to be pulled out as soon as possible.

Quarterboat No. 5 will not be pulled out until after the operations at the quarry are finished.

As soon as the repairs to the Elwood revetment are completed, the remainder of the fleet, consisting of 15 barges 25+100 feet, and the steamer *Alert* will be transferred to the Kansas City division.

Bon Ton revetment.—Final cost exhibit in detail to June 30, 1887.

Distribution.	Cost per unit.	Cost of 4,158 feet of revetment.	Cost per foot of revetment.
Procuring rock (9,617.33 cubic yards):			
Quarry privilege	$0.03		
Quarrying	.19087		
Stripping	.14456		
Hauling	.11188		
Loading barges	.09969		
Blacksmith	.00392		
Powder and fuze	.03989		
Subsistence	.16736		
Cost on barges	.78817		

Bon Ton revetment.—Final cost exhibit in detail to June 30, 1887—Continued.

Distribution.	Cost per unit.	Cost of 4,158 feet of revetment.	Cost per foot of revetment.
Producing rock (9,617.33 cubic yards)—Continued.			
Towing:			
Labor	.21660		
Fuel	.10906		
Cost at work	1.11383	$10,712.07	$2.576
Placing rock (9,617.33 cubic yards):			
Labor	.09184		
Subsistence	.05515		
	.14699	1,413.72	.340
Procuring brush (3,628.05 cords):			2.916+
On stump	.04852		
Cutting	.42707		
Binding	.16671		
Loading teams	.06349		
Hauling	.42168		
Loading barges	.15428		
Subsistence	.27900		
Cost on barges	1.56073		
Towing:			
Labor	.26610		
Fuel	.12931		
Cost at work	1.95614	7,256.76	1.75+
Weaving mat (4,696 lineal feet):			
Labor	.83769		
Subsistence	.53319		
	1.32913	6,242.18	[illegible]
Anchoring mat:			
Labor	.10262		
Cable, three-eighths inch	.17608		
Cable, three-fourths inch	.06801		
Subsistence	.06042		
	.40712	1,692.83	[illegible]
Grading bank (51,249.6 cubic yards):*			
Labor	.01313		
Fuel and supplies	.00386		
Subsistence	.00786		
	.02485	1,273.67	[illegible]
		28,591.23	[illegible]

*This includes grading by hand.

There remains to be placed on the mattress about 450 cubic yards of rock, which will add about 14 cents per lineal foot to the cost as given in the above exhibit, making the total cost of the revetment completed $7,015 per lineal foot, exclusive of administration, repairs to, and care of plant.

The fact that the cost of this season's work has exceeded in every item the estimated cost, has been accounted for in part above, but the chief cause must be attributed to the almost unprecedented demand for labor throughout the country. This resulted not only in a large increase of wages, but made impossible that thorough organization so essential to effective and economic construction. Attracted by rumors or seductive advertisements of larger pay and less work, or actuated by a Bohemian restlessness, the men would quit the work before they had become skilled in their duties. Hence the chief of a construction party, besides being continually handicapped by "green hands," could never tell in advance of a day's work how many men he would have.

With the completion of the repairs to the Elwood revetment this month the funds available for field work on the Saint Joseph division will have been exhausted and operations will be suspended.

There will then remain of the improvements projected by the Commission the following, viz:

In Bon Ton Bend:	
Revetment (extension down stream), 1,842 feet, at $6.35	$11,696.70
In Elwood Bend:	
Revetment (extension up stream), 11,400 feet, at $6.35	72,390.00
Add for administration, care, and repairs to plant, new plant, surveys, and contingencies	15,913.30
Amount necessary for completion of approved project	100,000.00

All of this amount could be expended in one year.

I am, colonel, with great respect, your obedient servant,

S. WATERS FOX,
Assistant Engineer.

Lieut. Col. CHARLES R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX C.

REPORT OF SECRETARY ON SPECIAL SURVEYS.

SAINT LOUIS, MO., *June* 30, 1887.

SIR: By the river and harbor bill approved August 5, 1886, appropriation was made for the Missouri River, "continuing improvement, including necessary work at Omaha, Atchison, Saint Joseph, Fort Leavenworth Reservation, Arrow Rock, Kansas City, Plattsmouth, Brownville, and Nebraska City." * * *

By resolution of the Commission, at its meeting August 26, 1886, an allotment of $10,000 was recommended for "securing data necessary for preparing the plans and estimates for necessary work" at each of the above mentioned places.

Said allotment was approved by the Hon. Secretary of War, October 28, 1886.

The surveys at Omaha, Plattsmouth, Nebraska City, Brownville, and Arrow Rock were made by a party in charge of Assistant Engineer W. Kiersted, jr. They began field-work November 15, 1886, and finished January 21, 1887. It was afterwards found necessary to extend the survey made at Plattsmouth farther up-stream; this was done during the latter part of May, 1887.

The surveys at Atchison and Fort Leavenworth were made by a party under Assistant Engineer G. T. Nelles. They began field-work November 25, 1886, and finished before the end of January, 1887.

The surveys at Saint Joseph and Kansas City were made under the direction of the respective division engineers in charge, S. W. Fox and S. H. Yonge.

All the maps have been plotted to a scale of 2,000 feet to 1 inch. They show shore-lines and bars of the latest surveys—shore-lines of surveys of 1879 and 1882, and areas of cuts in acres.

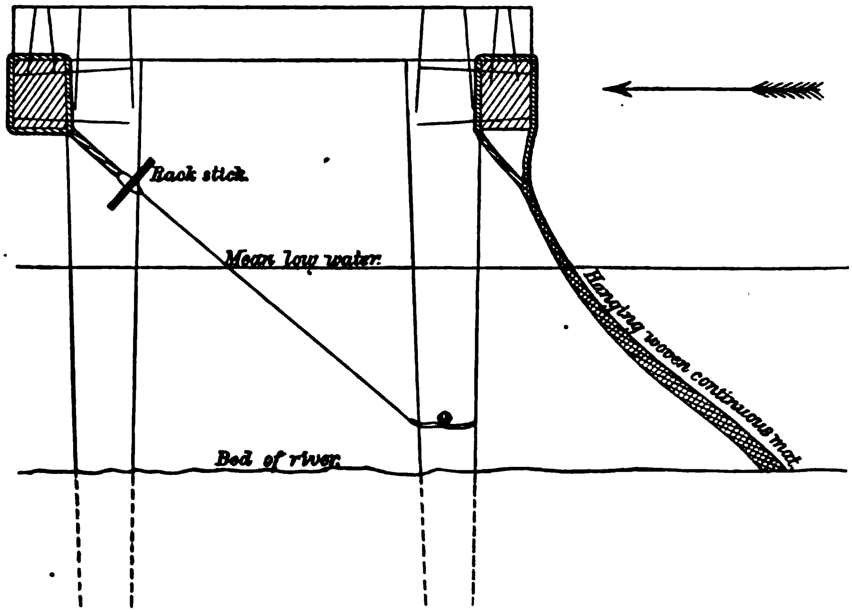
In the suggestions made in this report for works, protection of banks has been kept in view rather than improvement of navigation, because it is rarely possible to perfect a plan for the amelioration of the river at one locality by studying the conditions at that place alone. At the same time an attempt has been made to have the work suggested such as would be of value in improving the navigation.

In making up the estimates, the cost of revetment has been placed at $10 per linear foot, basing upon past experience on the Missouri River. This is for a width of 130 feet, which would probably not have to be exceeded.

The estimates for pile and mat dikes are based on close calculations, compared with the cost of the one built this season at East Bottoms, Kansas City. The cost is placed at $3 per linear foot.

The form of dike suggested is a double row of piles, driven about 20 feet and spaced 10 feet apart each way. A longitudinal waling, about 6 by 8 inches, is to be placed along the top of each row and spiked and wired in place; cap-sills are spiked and wired on top of each two piles in the direction of the current. Underneath and parallel to the cap-sills are to be ties of wire cable, fastened just above the river-bed to the up-stream pile, and to the top of the down-stream pile directly behind. This tie is drawn tight by a rack-stick. The design is practically that given in Annual Report Mississippi River

Commission, 1882, page 177. Top of dike to be about 5 feet above low water, so as to allow drift of high water to pass entirely over it. A section would be similar to the following figure:



On the up-stream side of the dike is to be suspended by wire cable a continuous woven mat, 30 to 50 feet wide, made with the double cross cables used this season at Saint Joseph and with two selvaged edges. Outer edge of mat resting on river-bed to be weighted with riprap.

In estimating the cost of plant a unit outfit has been taken, viz, that for one party to put in about 10,000 lineal feet of revetment in an ordinary working season. At some places, Omaha for example, several such outfits could be worked to advantage simultaneously. This outfit is:

2 mat-boats { 25 by 100 feet, at $4,500 or	$9,000
2 mat-boats { 16 by 46 feet, at $4,000 or	8,000
14 barges, 25 by 100 feet, at $2,000	28,000
4 barges, tenders, 16 by 64 feet, at $1,800	7,200
2 hydraulic graders, at $10,000	20,000
3 quarter-boats, 100 men each, at $4,000	12,000
1 tow-boat	20,000
Total	95,200
	or 96,200

FOR A PILE AND MAT DIKE PARTY.

1 mat-boat, about 16 by 64 feet, at $4,000	$4,000
10 barges, about 16 by 64 feet, at $1,800	18,000
3 quarter-boats, 50 men each, at $2,500	7,500
1 pile-sinker with tender, complete, at $8,500	8,500
1 tow-boat, at $20,000	20,000
Total	58,000

A few notes are given as to the conditions of each locality, and an attempt has been made to place the whole subject in a clear and concise tabular form.

A table is also given showing the relation between the cost of work suggested at the various localities and the values of land subject to erosion. The values of land given were obtained by inquiries at each locality.

OMAHA.

Erosion is going on actively at Tarbox Point, below Florence; also just above the northwest dikes; also on the left bank opposite the city of Omaha; also in the bend below the Union Pacific Railroad Bridge. There is said to be danger of a cut-off through Florence Lake, although, as the map shows, the lake was smaller in 1882 than in 1879. Some repairs are needed in the old revetment just above the city. The cut just below the city is detrimental to considerable business interests. The port is in good condition and can be kept so. The work suggested is:

Revetment:		
Right bank, Florence to "B"	feet	19,000
Left bank, "C" to N. W. dikes	do	6,000
Left bank, N. W. dikes to "X"	do	49,000
Right bank, below city	do	5,000
Left bank bend, below Union Pacific Bridge	do	15,000
Repairs to old revetment	do	500
Total	do	94,500
Cost, at $10 per foot		$945,000
Plant required, 3 unit outfits, at $95,200		285,600
Total		1,230,600
Amount that can be profitably expended during the first season, being cost of plant and first season's work		$600,600

Three seasons required to complete project.

PLATTSMOUTH.

The river here has changed greatly since the last survey, and is still changing rapidly. On the tongue of land between the two rivers a considerable cutting (85 acres) took place between December, 1886, and May, 1887. It seems certain that this point of land will soon disappear entirely. There is considerable cutting going on also at the foot of Pacific Bend—nearly 70 acres per year for the last seven years. If the bank in this bend and the tongue of land between the rivers were revetted and held, probably the bars in front of the town would be cut out and the port be improved. These bars were about 4 feet out of water when the last surveys were made. If the point between the rivers is cut out, the fill in the upper part of Pacific Bend will probably extend down to the foot; the Missouri will strike the right bank where the mouth of the Platte now is and be deflected against the left bank to a point opposite the town and above the bars now obstructing the port; and even if, for a time, the bars in front of the town are removed by these changes, a new bar will form below the mouth of the Platte, which will probably be a long one, reaching down along the town front.

But it appears that the river will again assume much the same condition it has now, because the foot of the bend next above Pacific Bend is cutting rapidly and its effect will be to carry the contact of the Missouri with the right bank up to the locality of Papillon Creek. The point of land between the two rivers would then doubtless form again, the lower end of Pacific Bend would begin to cut out again, and the state of affairs would be similar to the present one.

WORK SUGGESTED.

Revetment:		
Left bank, Pacific Bend, "F" to "G"	feet	13,500
Right bank, point between rivers, "C" to "D"	do	13,500
Left bank, bend above Pacific, "K" to "A"	do	12,000
Total	do	39,000
Cost, at $10 per foot		$390,000
Plant required, 3 unit outfits, at $95,200		285,600
Total		675,600
Amount that can be profitably expended during the first season, being cost of plant and first season's work		675,600

One season required to complete project.

NEBRASKA CITY.

As will be seen by the map, a great change has taken place here. The river has abandoned the chute on the left bank and follows the town front, a favorable condition for the port of the town. Considerable cutting has taken place below the town. A railroad bridge is to be built at the town in the near future, and the plans for it include the entire closing of the old channel, now the chute east of Nebraska City Island. As this plan, if executed, will confine the river to its present channel, no work near the town is suggested. Below the town the following work is necessary to hold the banks:

Revetment:	
Right bank, "K" to "L" ... feet..	10,000
Left bank, "M" to "N" ... do..	22,000
Total ... do..	32,000
Cost, at $10 per foot ...	$320,000
Plant required, three unit outfits, at $95,200 ...	285,600
Pile and mat dike to close chute, at "K," at head of proposed revetment, 500 feet, at $3 per foot ...	1,500
Plant required, one unit party, at $58,000, less $20,000 for tow-boat ...	38,000
Total ...	645,100
Amount that can be profitably expended the first season, being cost of plant and first season's work ...	645,100

One season required to complete project.

BROWNVILLE.

The cut below the town is the one that probably interferes most with the commercial interests of the place, although considerable farming land in the vicinity has been eroded since the last survey. The cutting near the town appears to be due to change in the angle of confluence between the main river and Sonora Chute.

As shown by the map, it is now nearly 90 degrees. This has had the effect of pushing the river over against the left bank, thus cutting that bank out. This action has moved the point of impact on the right bank down-stream and caused the erosion there shown. The 1879 shore line opposite the town was a favorable one, and as a means of restoring it pile and mat dikes are suggested, to be built from the point "A" down-stream, in echelon, about 1,000 feet apart, shortest farthest up-stream; longest will probably not need to be over 1,000 feet long; all to be perpendicular to the direction of the current and similar to the design already described.

The right bank should be revetted at the town between the points "F" and "G," and the head of this work may need to be secured by a pile and mat dike. Cutting at Sonora can be prevented by revetment from "C" to "B," and this involves the revetment of the right bank on the head of Sonora Island in order to hold the river in its present channel.

WORK SUGGESTED.

Pile and mat dikes at "A" and head of revetment above town ... feet..	3,500
Revetment:	
Right bank, "F" to "G" ... do..	25,000
Left bank, "C" to "B" ... do..	10,000
Right bank, "J" to "K," opposite Sonora ... do..	10,000
Total revetment ... do..	45,000
Cost, at $10 per foot ...	$450,000
Cost dikes, at $3 per foot ...	10,500
Plant required, 1 unit dike party ...	58,000
2 unit revetment parties, at $95,200 ...	190,400
Total ...	708,900
Amount that can be profitably expended the first season, being cost of plant and of first season's work ...	478,650

Two seasons required to complete project.

SAINT JOSEPH.

The last survey shows serious erosion below the bridge—about 190 acres in five years. The danger of cut-off through Lake Contrary, feared by citizens of this locality, is not regarded as at all serious. But protection of the caving bank would be of great value to the commercial interests of this city and section of country. Protection work is also needed in Elwood Bend, between the points marked "A" and "B" on the map. To hold the work already done on this reach, the bank should be revetted from the head of the old revetment "O" to "P" at Belmont; and to complete the protection of the banks at this point, revetment is also needed from the point "D" on the map, down-stream to a point near "E" (or "E′," if the river should return to its old bed).

WORK SUGGESTED.

Revetment:	
Right bank, "O" to "P" feet	11,400
Right bank, "A" to "B" do	4,500
Left bank, bridge to "C" do	21,700
Right bank, "D" to "E" do	12,500
Total do	50,100
Cost, at $10 per foot	$501,000
Plant required—two unit parties, at $95,200	190,400
Total	691,400
Amount that can be profitably expended first season (being cost of plant and of first season's work)	536,100

Two seasons required to complete project.

ATCHISON.

The chute through McQueen's Bend is a low-water one. During high water the main channel is along the eastern shore of Atchison Island, McQueen's Bend being at that time more or less silted up. Cutting in McQueen's Bend occurs only at a low-water stage. Below McQueen's Bend the bank cuts rapidly at high water, but very little as soon as the river gets down to an average stage. There is possibility of a future cut-off from Rushville Bend into McQueen's Bend.

WORK SUGGESTED.

Pile and mat dikes across head of McQueen's Bend Chute feet	3,000
Revetment:	
Left bank, dikes to Chicago and Alton Railroad Bridge do	27,000
Left bank, Rushville Bend do	25,000
Total do	52,000
Revetment cost, at $10 per foot	$520,000
Dikes, at $3 per foot	9,000
Plant required:	
1 unit dike party, at $58,000	58,000
2 unit revetment parties, at $95,200	190,400
Total	777,400

The Chicago and Alton Railroad Bridge as it stands is not perpendicular to the direction of the current. The works suggested would be likely to cut off the foot of Atchison Island to some extent and improve the passage for boats.

Amount that can be profitably expended first season, being cost of plant and of first season's work	$512,900

Two seasons required to finish project.

FORT LEAVENWORTH.

This is the most difficult of the localities under consideration to deal with. The principal trouble is with Kickapoo Slough. About 75 per cent. of the river passes through it with great velocity, and the depth is unusual. The right bank is cutting rapidly. As it is practically useless to attempt forcing the river directly, it is difficult to propose a sure remedy for this case as matters now are. Should the slough cut out wider, its right bank could be revetted and held, a difficult, if not impossible, matter with the present deep and swift current. As the matter stands the only work that can be estimated on is revetment of Kickapoo Slough, about 15,000 feet, and to complete the work in this locality and hold the river as it is, 18,000 feet of revetment in Bee Creek Bend, to protect the eastern approach to the Chicago, Rock Island and Pacific Railroad Bridge.

WORK SUGGESTED.

Revetment:	
Right bank, Kickapoo Slough .... feet..	15,000
Left bank, Bee Creek Bend .... do...	18,000
Total .... do...	33,000
Cost, at $10 per foot	$330,000
Plant required—3 unit parties, at $96,200	288,600
Total	618,600
Amount that can be profitably expended first season, being cost of plant and of first season's work	618,600

One season required to complete project.

KANSAS CITY.

The work here suggested is that not already allotted for by the Commission, and yet needed thoroughly to insure safety to navigation and business interests.

Revetment:	
Right bank, Little Platte Bend .... feet..	15,000
Left bank, Parkville Bend .... do...	13,000
Left bank, Kaw Bend Bar .... do...	7,000
Right bank, Wyandotte front .... do...	3,500
Left bank, Harlem front .... do...	8,000
	46,500
Cost, at $10 per foot	$465,000
Extra plant required, 2 unit parties, at $96,200	192,400
Total	657,400
Amount that can be profitably expended the first season	224,900

Two seasons required to complete work projected above.

ARROW ROCK.

Comparison of the shore-lines of 1879, 1882, and 1887 shows the usual movement down stream of bends and of the bars opposite their lower ends. In 1879 revetment of the left bank in Nigger Bend would undoubtedly have preserved the good port then existing. The last survey shows that a bar has begun to encroach on this port, although not seriously as yet. Work suggested:

Revetment:	
Left bank, Nigger Bend, A to B .... feet..	14,700
Cost, at $10 per foot	147,000
Plant required, 2 unit parties, at $96,200	192,400
Total	339,400
Amount that can be profitably expended the first season	339,400

One season required to complete work as projected above.

Value of land, probable market price, etc.

Locality.	Value of land per acre.			Average acres per year moved by river.		Values of land.		Cost of improvement suggested.
	Assessed.	Probable market price.						
		Unprotected.	Protected.	Cut.	Fill.	Eroded.	Filled.	
Omaha:								
Front	*$2,400.00			4		$9,600		
Farms in vicinity	10.00 to 15.00			95		1,140		
Bottom above city	*80.00							$1,230,600
Plattsmouth:								
Front		$50		30		1,500		
Farms	*4.50			125		563		675,600
Nebraska City:								
Front		120						
Farms		$15 to 20						645,100
Brownville		10 to 15		125		1,500		708,900
Saint Joseph:								
French bottom		30	$60					
Ellwood bottom †		*50			239		$11,950	
Bend below bridge ‡		*45		48		2,138		691,400
Atchison:								
McQueen's Bend		60		105		6,300		
Head Atchison Island		40						777,400
Fort Leavenworth:								
Vicinity Cow Island		40		114	22	4,560	880	
Oak Mills		50			103		5,150	
Vicinity Kickapoo Island		100						
Vicinity Bee Creek Bend		75		74		5,550		
Vicinity Spar Island		50						618,600
Kansas City:								
Parkville		75		13		975		
Quindaro§		(‖)	300					
East Bottoms		(‖)	¶1,000					
Sharp's Bend**		1,000						657,400
Arrow Rock		25		71		1,775		339,400

* Average.
† North bank is revetted.
‡ "Boom" price, $1,500 per acre.
§ Since revetment.
‖ Not salable.
¶ And upwards.
** Owing to work in East Bottoms.

Assistant Engineer S. W. Fox reports the average value of Missouri River land at $10 per acre; if reveted, at $50 per acre; counting cost of revetment at $10 per linear foot.

Work suggested, plant required, etc.

Locality.	Work suggested.				Plant required.					
					Mat boats.			Barges.		
	Revetment.	Estimate.	Pile and mat dike.	Estimate.	Number.	Size.	Estimate.	Number.	Size.	Estimate.
	Feet.		Feet.			Feet.			Feet.	
Omaha	94,500	$945,000	....	....	6	16 by 64	$24,000	42 12	25 by 100 16 by 64	$84, 21,
Plattsmouth	39,000	390,000	....	....	6	16 by 64	24,000	42 12	25 by 100 16 by 64	84, 21,
Nebraska City	32,000	320,000	500	$1,500	7	16 by 64	28,000	42 22	25 by 100 16 by 64	84, 39,
Brownville	45,000	450,000	3,500	10,500	5	16 by 64	20,000	28 18	25 by 100 16 by 64	56, 32,
Saint Joseph	50,100	501,000	....	....	6	16 by 64	24,000	42 12	25 by 100 16 by 64	84, 21,
Atchison	52,000	520,000	3,000	9,000	5	16 by 64	20,000	28 18	25 by 100 16 by 64	56, 32,
Fort Leavenworth	33,000	330,000	....	....	6	25 by 100	27,000	42 12	25 by 100 16 by 64	84, 21,
Kansas City	46,500	465,000	....	....	4	25 by 100	18,000	28 8	25 by 100 16 by 64	56, 14,
Arrow Rock	14,700	147,000	....	....	4	25 by 100	18,000	28 8	25 by 100 16 by 64	56, 14,
	406,800	4,068,000	7,000	21,000	35 14	16 by 46 25 by 100	140,000 63,000	322 122	25 by 100 16 by 64	644, 219,

Locality.	Plant required.								
	Quarter boats.			Hydr. graders.		Tow-boats.		Pile sink	
	Number.	Accommodate. (Men.)	Estimate.	Number.	Estimate.	Number.	Estimate.	Number.	Estimate.
Omaha	9	Each 100	36,000	6	$60,000	3	$60,000	....	....
Plattsmouth	9	Each 100	36,000	6	60,000	3	60,000	....	....
Nebraska City	3 9	Each 50 Each 100	7,500 36,000	6	60,000	3*	60,000	1	$8,
Brownville	6 3	Each 100 Each 50	24,000 7,500	4	40,000	3	60,000	1	8,
Saint Joseph	9	Each 100	36,000	6	60,000	3	60,000	....	....
Atchison	6 3	Each 100 Each 50	24,000 7,50C	4	40,000	3	60,000	1	8,
Fort Leavenworth	9	Each 100	36,000	6	60,000	3	60,000	....	....
Kansas City	6	Each 100	24,000	4	40,000	2	40,000	....	....
Arrow Rock	6	Each 100	24,000	4	40,000	2	40,000	....	....
	69 9	Each 100 Each 50	276,000 22,500	46	460,000	25	500,000	3	25,

Locality.	Total estimate for works.	Total estimate for plant.	Aggregate.	Estimate for first year's work.	Number years to complete project.
Omaha	$945,000	$285,600	$1,230,600	$800,600	
Plattsmouth	390,000	285,600	675,600	675,600	
Nebraska City	321,500	323,600	*645,100	645,100	
Brownville	460,500	248,400	708,900	478,650	
Saint Joseph	501,000	190,400	691,400	536,100	
Atchison	529,000	248,400	777,400	5'2,900	
Fort Leavenworth	330,000	288,600	618,000	618,000	
Kansas City	465,000	192,400	657,400	224,900	
Arrow Rock	147,000	192,400	339,400	339,400	
	4,089,000	2,255,400	6,344,400	4,631,850	....

*Tow-boat for exclusive use of dike party omitted in this estimate.

The plant estimated for is in addition to that already in the possession of the Com- mission.

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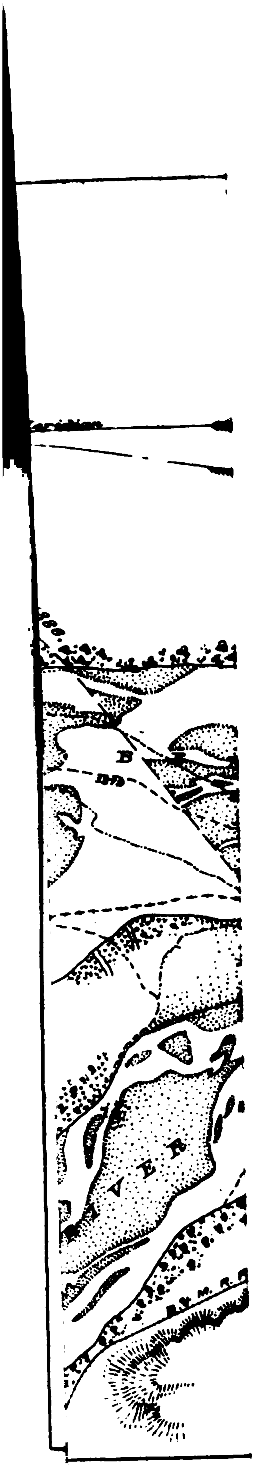
St. Louis. Mo. September 15. 1887.

ded with annual report for 1887.

Theo. A. Bingham

1st Lieut. of Engineers

Missouri River Commission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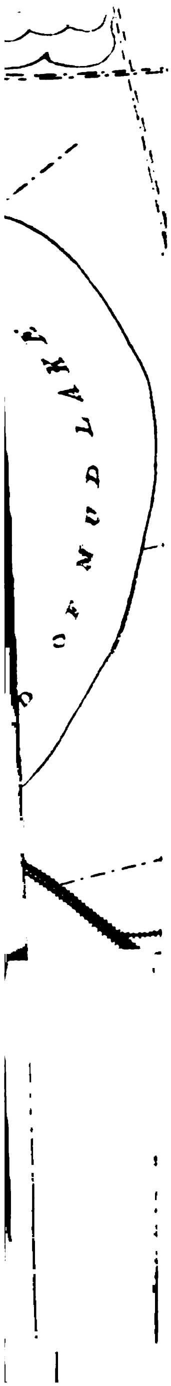
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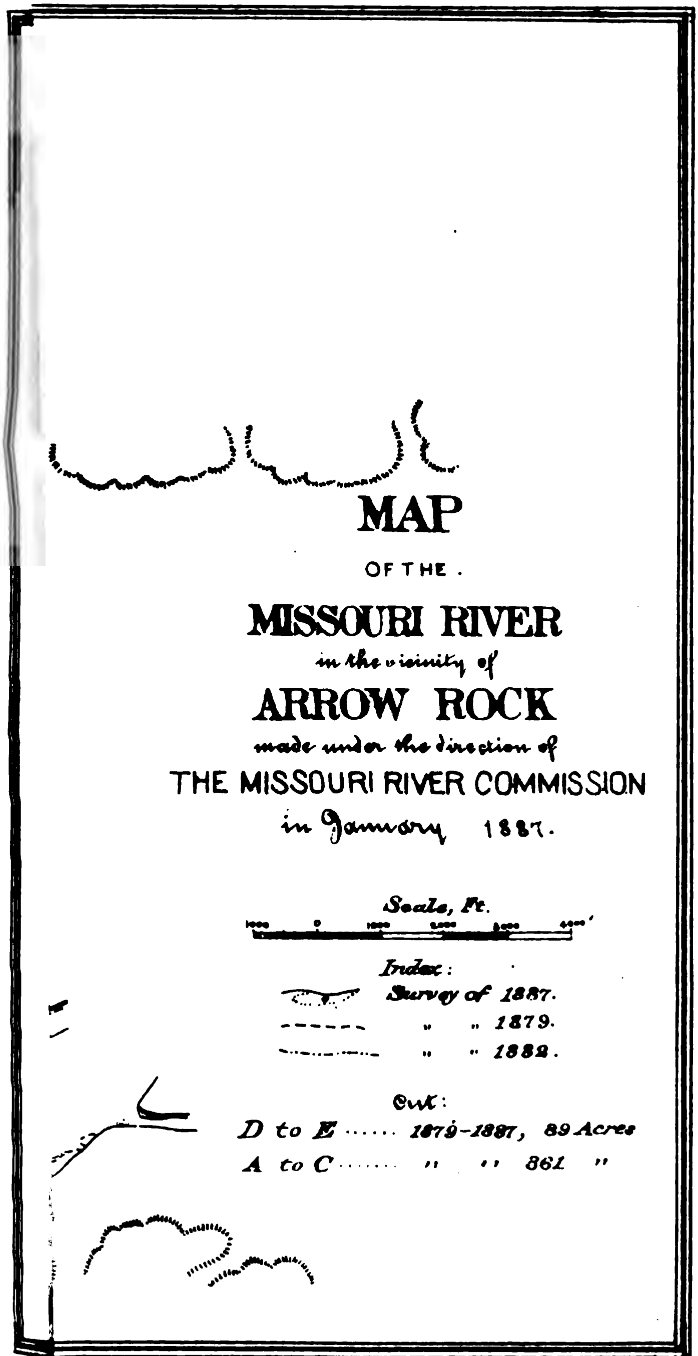

MAP
OF THE
MISSOURI RIVER
in the vicinity of
ARROW ROCK
made under the direction of
THE MISSOURI RIVER COMMISSION
in January 1887.
Scale, Ft.
Index:
Survey of 1887.
" " 1879.
" " 1882.
Cut:
D to E ...... 1879–1887, 89 Acres
A to C ...... " " 861 "

APPENDIX D.

REPORT OF SECRETARY ON OBSTRUCTION TO NAVIGATION AT CAMDEN, MISSOURI.

SAINT LOUIS, MO., *June* 30, 1887.

SIR: In accordance with resolution of the Commission at its last meeting, I have the honor to submit the following report on the obstruction to navigation at Camden, Mo., reported by Captain Tilden in letter of May 10, 1887:

In company with yourself I visited Camden May 14, 1887, on the steamer *William Stone*. When near the dike constructed by the Wabash Railroad Company there, which forms the obstruction referred to, the steamer *Wyoming* was coming up through the obstructed channel. She had failed on the first trial, but succeeded on the second. An inspection of the channel at the dike was made by Captain Patterson in a skiff, as it was not deemed advisable to get the *Stone* too near the dike, since she might have to go below it and might have serious difficulty in getting back. It was reported that the dike was continuous from the left bank across the channel to the bar on the west side. A sort of waste-weir had been left in the middle for the passage of boats. The end of the dike on the bar was under water. The velocity of the water over the waste-weir was estimated at 5 to 6 miles per hour, and there was a sudden drop of 8 to 10 inches just at the lower edge. Depth of water on upper side of dike was over 10 feet, but there was only 4 feet over the dike.

I called on the railroad foreman in charge of building the dike. He said the object was to throw the river over against the right bank and prevent cutting in Camden Bend, which was seriously threatening railroad property. It was expected that the dike would be finished in time for the June rise, at which time these changes were expected to take place. Ways had been built on the bank, just above the dike, for construction of the mats used in its construction. These mats are woven of willow poles, about 90 by 40 feet and 6 to 8 inches thick. When two of these are launched they are floated in position, side by side, lengthwise of the stream, and sunk with riprap. Successive layers on top of each other constitute the dike.

In order to determine exactly the effect of this obstruction, a survey was necessary. This was made in the latter part of May and first of June. The results are shown on the map herewith. Unfortunately the survey had to to be made at a high stage of water, about 7 feet above low. At the time of the inspection above mentioned, the bar shown on the map, as it existed in 1882, had worn away somewhat, and its upper end, on which the outer end of the dike rested, was more nearly opposite the line of the dike. At the time of the survey this bar had worn away much more, as seen by the map, and the river had followed its usual course of cutting around the end of the dike and undermining it. Owing to this fact and the swift currents and great fall at the dike, it was not found possible to locate the present outer end of the dike. Numerous cross-sections and miscellaneous soundings were made. These are shown on the map. Floats were run to show the direction and velocity of the current. Their directions are shown on the map with the points where they cross the sounded sections and with the velocity along each line. Sections 13, 13 A, and 15 show where the outer end of the dike was, viz, on the bar visible at low water. By sections 10, 11, 13, 13 A, 15, and 16 the main channel is still seen to be over the waste-weir of the dike before mentioned. The split in the channel is shown by section 16 to be due, not to the dike, but to the tow-head below. The main channel is still down the bend. There is a channel on the west side from the head of the bar, turning sharp off toward the west bank and following this down, gradually working back to the main channel along the left bank. This western channel is a very tortuous one, as shown by the map, and by the letter of Captain Keith, hereto appended; for from the head of the bar it leads out around the end of the dike. The bar shown on the map is gradually wearing away at its upper end, and there is every evidence that the only channel will soon be in the bend where it was before, only with its point of impact moved further down-stream.

So there the dike is right across the main channel, with an excessive fall on its lower edge, an excessive velocity over it, owing to its damming effect, a most serious and unwarrantable obstacle to navigation. The channel has only been divided temporarily, and not totally diverted.

Several letters on this subject are appended, as further evidence of the nature of this obstruction, which, it appears, the railroad company propose to repeat at De Witt.

Prompt measures should be taken, if the Wabash Western Railroad Company are to be prevented from seriously endangering the navigation which the Commission are at work to improve.

Respectfully submitted.

THEO. A. BINGHAM,
First Lieutenant of Engineers.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

LETTERS OF CAPTAIN C. B. TILDEN.

1.

KANSAS CITY, MO., *June* 28, 1887.

LIEUTENANT: The main channel of the river at Camden is still over the dike and down the bend, same as when you were up here. But at the present high stage of water in the river there is plenty around the end of the dike, but crooked and very hard to make.

There is a middle chute that looks very well, but which I did not try, and still another, going over to the point, which I ran several times and found abundance of water. Of course, at the present high stage, it is impossible to say where the channel will be when the river falls, but I think it will remain over the dike and down the bend, same as when you were up here. I will see the pilots on the steamers *Dacotah* and *Wyoming* when they come up and obtain their views on the subject and transmit them to you as early as possible.

I am, sir, very respectfully, your obedient servant,

C. B. TILDEN.

Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.

2.

KANSAS CITY, MO., *July* 20, 1887.

LIEUTENANT: Your letter of July 19 was received to-day. In reply I would say that I saw Capt. Henry Keith, of the steamer *Wyoming*, on July 2, and gave him a rough draught of a letter to you expressing his views of the river at Camden, and which he was to have signed by himself and the pilots of the *Wyoming* and then take it down to Saint Louis and get it signed by the captain and pilots of the steamer *Dacotah* and forward to you. The steamer *Dacotah* had broken her shaft on her trip up the river, and returned to Saint Louis for repairs, and has not since been up here.

I saw Captain Keith on Monday, the 18th instant, and asked him about it. He said he had no opportunity of getting it signed, but would attend to it on his return to Saint Louis. In case he does not do it, however, I give you below the substance of what he said about the place: "The channel at Camden was still down over the dike, and there was little or no water the other way outside, and that owing to this dike it was the most dangerous place on the river to navigate.

I am, sir, very respectfully, your obedient servant,

C. B. TILDEN,
Captain.

Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.

3.

KANSAS CITY, MO., *July* 25, 1887.

LIEUTANANT: I, this morning, saw Capt. George Keith, of the steamer *Dacotah*, who arrived here last evening with his boat. On speaking of the dike at Camden, Mo., he says "that he came up the middle chute and around the head of the dike, that the reef makes in very close and that the current is very swift, making it the most dangerous place on the river to navigate."

He also reports a dike in the course of construction below DeWitt, Mo., which, if carried out, as apparently projected, will be equally bad as the dike at Camden, piles having been already driven two-thirds of the distance across the river. He told me he would address a letter to you at once relative to this matter.

I am, lieutenant, very respectfully, your obedient servant,

C. B. TILDEN,
Captain.

Lieut. THEO. A. BINGHAM,
Corps of Engineers, U. S. A.

LETTER OF CAPTAIN GEORGE D. KEITH.

LEXINGTON, MO., *July* 26, 1887.

DEAR SIR: The dike put in below Camden is proving a great obstruction to navigation, and is giving us a good deal of trouble both in going up and coming down stream. They are also putting in dikes below DeWitt, which will cause great trouble to navigation. I also wish to call your attention to the Randolph Bridge, which, I am satisfied, it will be impossible to pass under during high water, and hardly think it is 50 feet above high-water mark. I would feel deeply obliged if you would examine into these matters, as it affects the interests of and would confer a great favor on steam-boat men generally on Missouri River.

Respectfully yours,

GEORGE G. KEITH,
Master Steamer Dacotah.

Lieut. THEO. A. BINGHAM,
Secretary Missouri River Commission.

APPENDIX E.

INSTRUMENTS AND METHODS USED IN TAKING AND REDUCING SEDIMENT AND VELOCITY OBSERVATIONS ON THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS, 1879.

DREDGE-BUCKET, SHEET NO 1.

For obtaining large samples of the river bed, which were afterwards analyzed at leisure. Samples obtained in this way were found to give a fairer determination than those obtained with a greased lead.

The bucket, as shown, was made of sheet-iron. Across the top is an iron bar with its ends bent at right angles in opposite directions, the hooks so formed being riveted to the sides of the bucket (Fig. 3). Above this bar and riveted to the sides of the bucket is an annular lip with beveled edge, to facilitate entrance of the bucket into the river-bed (Fig. 2). Between the cross-bar and bottom of the bucket is a sleeve, through which passes an iron rod with an eye at the upper end and a hook at the lower, the whole held in place by a nut at the bottom outside the bucket (Fig. 2). Between the bucket and the lead ball is inserted a swivel-joint (Fig. 1). The lead ball keeps the pull on the bucket more nearly horizontal. The anchor in rear of the bucket is to prevent the bottom of the bucket from rising as the lip enters the river-bottom.

SLIP-BOTTLE, SHEET NO. 2.

Used for obtaining samples of subsurface water normally charged with sediment. The design is similar to that used on H. M. ship *Challenger*, although this fact was not known until the device was ready for use. This "bottle" holds one-tenth of a cubic foot, and can be used at any depth. After filling, the contents were poured into a vessel, violently agitated, and the required samples taken out. Experience showed, however, that the sediment had partially settled when the bottle came up, and that mechanical agitation did not restore the normal distribution so as to render the small samples trustworthy.

SLIP-BOTTLE, SHEET NO. 3.

To obviate this difficulty this bottle was designed: It has two receptacles, of 2 fluid ounces each, the exact quantity required for each sample.

Each bottle is of two parts, a hollow cylinder with four short horns, ninety degrees apart, projecting radially from its upper edge and outer surface; and a piston of the same length as the cylinder, having the exact cubic contents of 2 fluid ounces, cut out by two rectangular slots, cut at right angles in such a manner that the piston becomes two disks, separated by four posts. From the lower surface of the piston projects a cylindrical pin, with a turned neck, by which connection is made with the other parts of the machine.

The closing mechanism consists primarily of a post, with a cylindrical opening running throughout, but reduced at the upper end; within this opening is fitted a piston-head, having a stem running through the reduced opening at the upper end, and attached

to a cross-head and grip-handle by a through key. Between this pisto reduced opening there is a spiral spring. Through the piston-head, at the axis of the post, a tumbler-pin is driven, passing through opposite an cut through the walls of the hollow post, and projecting sufficiently to two sear-hooks when the piston is raised and the spring compressed.

The sear-hooks are connected by a swivel-pin and ring to the line machine is raised and lowered.

At right angles to the cross-head, and opposite the sear-hooks and center post, and supported from it by a lug at each end, is a pipe with five times the diameter of the standing wire. An open slit is cut thr and pipe sufficiently large to allow the standing wire to be introduced which the pipe may be revolved part of a turn, so that the solid parts o cover the open parts of the pipe and thus prevent the possibility of diseng

At the lower end of the post there are two opposite and radial disk pl upper end, directly above these plates, are two radial arms, each carryi box at its extremity, the center of which perforation lies directly over th disk below, and through each hole there is a vertically sliding rod, havi end a four-armed spider, and at its upper end a simple swivel connection head.

From the outermost point in the circumference of the lower disk plates cut of a breadth just equal to the diameter of the turned neck in the bo length just sufficient to allow the center of the bottle, when the neck is sli to correspond with the center of the disk plate and the vertically sliding rod is prevented from sliding out by a latch-spring, which is automatically com the bottle is being slid into place, and is easily depressed by the little fin bottle is to be removed.

The machine was used by lowering it gently upon a standing line of No. when at the proper depth giving a sharp jerk to the lowering rope, which bells, and the machine was then drawn up.

TRANSPORTATION OF BOTTLES AND BOXES, SHEET NO. 4.

The samples of water were taken at eight locations distributed across the r three points for each location, viz, surface, mid-depth, and 1 foot above bo of each pair of surface samples was poured into a pint bottle for an average s ple, and the same for mid-depth and bottom, giving each day three pint bot were called the horizontal combinations. The remaining samples were co tically, the three at each location being poured into a 6-ounce bottle to obta age sample in that part of the river where they were taken ; this gave, in a the three pint bottles, eight more 6-ounce bottles for the day's work. The sa treated in the office, being sent in boxes shown on Sheet No. 4. One kind he one pint bottles, and another fifty-six 6-ounce bottles, being a week's suppl Boxes and bottles were returned weekly.

FILTRATION, SHEET NO. 5.

The method adopted for determining the amount of sediment was that of After experiment and study of the subject it was found necessary to use artifici drying the filter-papers, and the apparatus shown on Sheet No. 5 was design heat was supplied by a gasoline stove, and a temperature of 130° Fahr. was tained.

Full details are given under the head "Methods," below.

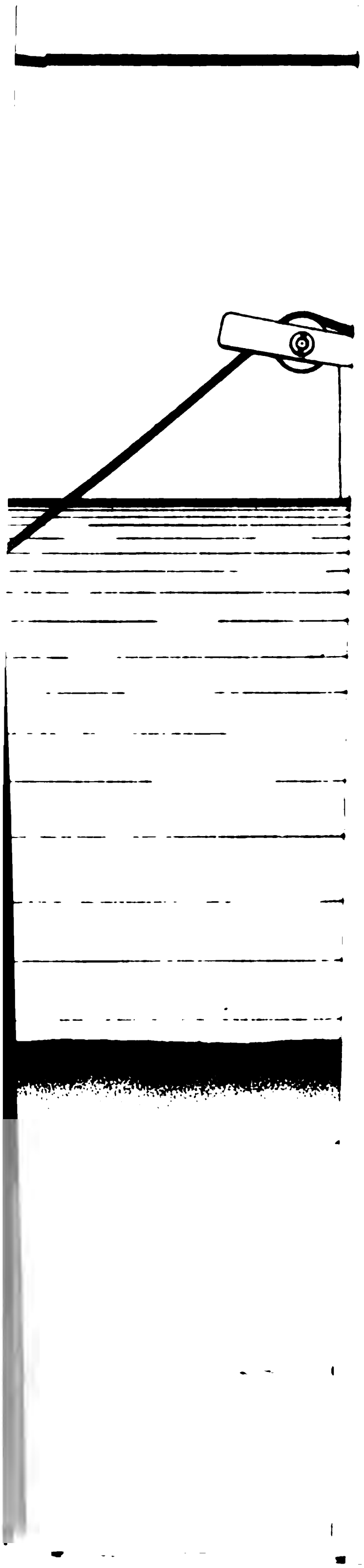
ELECTRIC APPARATUS FOR DISCHARGE OBSERVATIONS, SHEET NO. 6.

In making velocity observations the passage of the floats was signaled from range by electricity. The cells used were the Grenet, and they were arranged in as shown by Sheet No. 6.

DOUBLE FLOATS AND REEL FOR DISCHARGE OBSERVATIONS, SHEET NO. 7.

These were based on the Ellis floats used on the Connecticut River, and are tho to be an improvement on them.

The lower float is a cylinder of tin, 8 inches high and 8 inches in diameter. It h triangular air-chamber extending from the middle to the top, and is ballasted w



rim of lead 1 inch wide and one-sixteenth of an inch thick, soldered to the bottom of the cylinder on the inside. Two wires cross at the center of figure where the connecting line is attached.

The construction of the upper float is shown by the drawing. The lower part is a semi-ellipsoid, the upper part a very flat cone, having an altitude of one-eighth of an inch on a base of 8¼ inches. A tube three-eighths of an inch in diameter passes through the center.

The connecting wire was of annealed iron, No. 26, B. W. G., or .018 inch diameter, and the reel was used to avoid weakening the wire by kinking, as well as to facilitate handling.

An average of the floats sent into the field gives the following:

	Ounces.
Lower float:	
Weight in air	38
Weight in water	12
Displacement	26
Upper float:	
Weight in air	9
Displacement	24
Additional weight required to just sink the combination	3

The moment of stability of the lower float is about nine-elevenths that of the Ellis float, while it weighs considerably less in air and 50 per cent. more in water. It also presents an edge of one-sixteenth of an inch in width to the action of upward currents, and the air chamber is of a form which will resist the collapsing pressure of deep water. The upper float was designed to offer a minimum surface to the wind, and also to have its free buoyancy brought into play with the least possible vertical motion.

In the field the floats were found to have one defect, that of great delicacy and corresponding difficulty in handling. Constant complaint was made of the fragility of the wire and the want of free buoyancy of the combination. Several sub-floats were lost from the former, and many observations partially or wholly lost from the latter cause.

METHODS.

In determining the sediment from the samples of water collected, the method followed was that of filtration. Experiments were made on several kinds of filters and various ways of handling them. The Swedish, two grades of German, and French filters were tried, and it was found that they were effective in the order named, but only the best Swedish gave a clear filtrate. Water passed through four French papers still had a perceptible quantity of sediment in it, while one Swedish paper was sufficient to remove every trace, except under the microscope, which showed a few grains of less than one twenty-thousandth of an inch in diameter.

Numerous experiments upon drying, spontaneously and by absorbents, resulted unsatisfactorily, while showing that, for small quantities of sediment, the error introduced by an undetected change in the hygrometric state of the filter might seriously affect and even reverse the result. Recourse was then had to artificial heat, and the trials were so satisfactory that it was adopted.

The filters were prepared by carefully counterpoising two of them by trimming and then comparing the rest with one of these standards and noting the difference of weight. The other standard was kept with the papers during the weighing and put into the scale pan from time to time, and if any difference of weight appeared it was noted and used as a correction.

In treating the samples, the bottles were uncorked and the clear water carefully poured off into a measuring tube, graduated to cubic centimeters, and the volume noted. It was then poured back into the bottle and the tube rinsed out with filtered water, which was also poured into the bottle. The corks were then replaced and the bottles violently shaken, after which the contents were poured upon the filters, the bottles rinsed with filtered water, and the product added to the proper filters. The standards were put into the funnels and treated with the same amount of filtered water.

While the papers were still wet they were transferred to the drying box, which had been previously heated to the proper temperature, when one of the standards was placed in the hottest and the other in the coolest part of the box. The two standards were taken out from time to time and placed in the scales. At first the one in the hottest position would weigh the less, but their weight gradually approached each other until they finally balanced. After this it was found that their balance remained perfect, no matter how far the drying was pushed. They were left in the box a few minutes after they had balanced, in order to insure the same hygrometric state in all the papers.

When taken from the drying box the papers were placed on a rack beside the weighing case, one of the standards being placed in the center of the group and the other in the scale-pan. As soon as the papers were cool the standard on the rack was counterbalanced against the one in the case and the difference noted. The papers were then compared with the standard in the case and the difference of weight noted. The comparison of the standard was repeated two or three times during the weighing and at the end. The results gave a column of corrections which, when applied to the observed weights, transferred them from the standard in the case to that in the rack. By this indirect process the papers were compared with a standard which remained in the rack with them.

One source of error was detected and guarded against. When the papers contained a considerable quantity of sediment, it was found that the amount of moisture in the sediment itself varied perceptibly during the weighing, while the use of the standard eliminated only the variation of moisture in the paper. To correct for this, in heavy samples, the first paper weighed was repeated from time to time and its variation noted, which gave a correction for the moisture in the sediment, reducing all papers to the time when the first one was weighed.

In this way the sediment in milligrammes per pint was determined, after which the total sediment was computed as given in "Notes on sediment observations of 1879 at Saint Charles, Mo.," annual report, Missouri River Commission, 1887.

Observations for velocity were made in the following manner:

Three range lines at right angles to the current and 100 feet apart were located, and their intersections with a base line on shore, perpendicular to them, were permanently marked. Each of these three stations was occupied by an observer with an instrument, signals were given by means of an electrical apparatus, and time was noted by stop-watches, beating one-sixth of a second. Each party was provided with two of these watches.

The floats were put out from a floating skiff, and, having started, they were located on the three lines, each observer touching his key as the float crossed his range, at which signal an angle to the float was taken; for the upper range by the lower observer, for the middle range by upper and lower observer, and for the lower range by the upper observer. The skiff, meantime, followed directly in the path of the float and sounded, as nearly as could be judged, at the point where it crossed each range. Both of the watches were started at the first signal, one was stopped at the second, the other at the third signal. The floats were run as nearly as possible at mid-depth, a latitude of four-tenths to six-tenths of the depth being allowed.

The discharges were originally calculated by the method of partial areas, using the actual velocity along the float-path.

Afterwards, however, the Saint Charles discharges on the Missouri River were recomputed by the graphic method, using normal velocities, as given in "Notes to Missouri River discharge observations," annual report, Missouri River Commission, 1887. The difference in value resulting from these different methods of compensation was, in the main, quite small.

APPENDIX F.

REPORT ON REDETERMINATION OF STANDARD STEEL TAPE FROM MEASUREMENT OF ENTIRE OLNEY BASE, ILLINOIS, 1887.

The work was done by Assistant Engineers O. B. Wheeler, C. V. Mersereau, and R. F. Grady.

The preparations, method, tape, and adjuster were the same as described in Appendix A 3 of annual report of this Commission for 1886.

The first measurement was attempted on a warm, calm, overcast night, after a day which had threatened rain. The zincs had not been placed, and it required so much time to place them that only the east half was measured.

The second measurement was made at night after a day that had been for the most part cloudy and comparatively cool. There was an exceedingly heavy dew, so that tape and thermometer were covered with water.

The third measurement was made at night, after an overcast, cool day, with rain at noon, but clearing late in the afternoon.

There is open prairie on more than one-half of the 4.10 miles base, and herds of cattle, pasturing there, by rubbing on the stakes, disturbed them, sometimes breaking them down, and it was necessary to go over the line by day before each measurement and re-

align the nail-heads, and the alignment was never as good again as when first made. The results are, however, very accordant.

Two nearly identical values for one tape length (l) from o graduations to the 299-foot graduation are found from the following equations from the measurement of the entire base on the nights of the second and third measurements:

$$(1)\ 72l+\frac{l+1\text{ foot}}{3}-13'.0634+2'.8342-0'.1877+0'.6269=21623'.6552$$

$$(2)\ 72l+\frac{l+1\text{ foot}}{3}-12'.8545+2'.8342-0'.1877+0'.4219=21623'.6552$$

from which, by transposing the known quantities, we have:

$$(1)\ 72\tfrac{1}{3}l=21633'.1119 \text{ or } l=299'.07528$$
$$(2)\ 72\tfrac{1}{3}l=21633'.1080 \text{ or } l=299'.07522$$
$$\text{Mean } l=299'.07525$$

In these equations the terms are:

First term is number of entire tape lengths (o to 299-foot graduation).

Second term is fractional tape length between mark on zinc 72 and the mean of three marks on zinc 72 *a*, which latter marks were from three successive applications of 100 feet portions of tape under a strain of 16 pounds, and for the last 100 feet applying 1 foot of a box-wood scale to the 299-foot graduation to make out the 100 feet.

Third term is a distance measured on a straight edge with a box-wood scale from the mean of the three marks on 72 *a*, above noted, to △ west base. (This distance was checked by measuring from the 90-foot graduation of tape to △ west base.

Fourth term is total distance set forward on zincs. (See tables appended.)

Fifth term is inclination of tape correction. (See tables appended.)

Sixth term is temperature correction to reduce *first* and *second* terms to 62° Fahrenheit. (See tables appended.)

The *second member* is the known distance between △ east base and △ west base. (See page 303, No. 24, of Professional Papers, Corps of Engineers.)

A nearly identical value for l is found from the following equations from the measurements of the east half of the base, in which equations the terms are the same as above described, except that for 72 *a*, 100 feet and △ west base must be substituted 36 *a*, 50 feet and △ middle base, respectively, and in the second term for 3 substitute 6.

$$(3)\ 36l+\frac{l+1\text{ foot}}{6}+4'.3700+0'.0000-0'.1405+1'.0354=10821'.9662$$

$$(4)\ 36l+\frac{l+1\text{ foot}}{6}+3'.9458+0'.9092-0'.1405+0'.4197=10821'.9662$$

$$(5)\ 36l+\frac{l+1\text{ foot}}{6}+4'.1734+0.'9158-0'.1405+0'.2931=10821'.9662$$

from which, by transposing the known quantities, we have

$$(3)\ 36\tfrac{1}{6}l=10816'.5346 \text{ or } l=299'.07469$$
$$(4)\ 36\tfrac{1}{6}l=10816'.5753 \text{ or } l=299'.07581$$
$$(5)\ 36\tfrac{1}{6}l=10816'.5577 \text{ or } l=299'.07532$$
$$\text{Mean } l=299'.07527$$

This value for l is not independent of that from equations (1) and (2), but, being practically the same, it is preferred to consider the former value, only, in combining with the former determination. The former determination gave $l=299'.079$ (see last annual report, Appendix A 3°), which combined with that from equations (1) and (2), above, with equal weight, gives $l=299'.07713 \pm 0'.00126$—neglecting the probable error due from the primary base, which would increase this less than one in the last place. This probable error is one in 240,000. Although this difference in the two determinations is greater than would be expected from the accordance of single values in each determination, yet a probable error of one in 240,000 in this standard of length in a system of secondary triangulation, where, in the reading of angles, a station is occupied but once and readings are made under nearly all conditions of weather, should be considered satisfactory. Nor need the former computations with the larger values for l be recomputed with this new value.

I would offer the following reasons for giving the two determinations equal weight:

The measurements of 1885 were entirely by daylight on a very favorable, overcast day, while those of this year were entirely by lamplight. By daylight it was possible to see for a certainty that there was no twist in the tape, that the alignment was good, and that the bubble of the level for the horizontal lever arm was well centered, all of which could not be as well attended to by night, and an error in any one of these adjustments would tend to give a smaller value than the true. Also, there was less uncertainty by day than by night in bringing the zero (0) graduation of the tape (which is by the way too coarse a mark) to the mark on the zinc, and there may have been a large personal equation between Messrs. Grady and Sanders in doing this. On the other hand and in favor of the smaller value may be stated that it is from measurements of the entire base, and there was no uncertainty in regard to the hanging of the weight can on the hook of the horizontal lever arm as in the first determination. (See last annual report, Appendix A 3°.) A close examination of what this error might have been shows that in one position of the bail of the can the bearing on the horizontal lever arm would have been thrown out 0.27 inch, which would have stretched the 0′.00249, and using this as a correction instead of 0′.00085, the result would have been 299′.07746, or essentially the value I would now adopt.

The value I would adopt is:

$$l = 299'.07713 \pm 0'.00126 \text{ at } 62^\circ \text{ Fahrenheit and 16 pounds tension.}$$

In conclusion, allow me to state that I have more confidence now than ever before in the steel-tape measurement. But I would introduce one other refinement and take double the time and care in preparing and measuring the base if I wished to insure an accuracy of about one in one million. I would introduce the use of two microscopes of low magnifying power, each to be supported over the zinc strip on a side-arm from its platform, which rests on a horizontal board support for the zinc strip. While the forward observer is numbering his mark on the zinc a man brings the rear microscope forward and then guards the forward microscope until the rear observer arrives. The matter of temperature seems now to be under good control, since the extreme difference as given by two thermometers is, for the means, only 0°.15.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Engineer.

First Lieut. T. A. BINGHAM,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

Temperatures, Olney base.

[G thermometer is the compared "tape thermometer" of the Mississippi River Commissi thermometer belongs to the Missouri River Commission, and has been independently con with the "tape thermometer" for the above corrections.]

Number of tape.	First measurement.			Second measurement.			Third measurement.		
	Time.	Thermometers.		Time.	Thermometers.		Time.	Thermometers.	
		G.	R.		G.	R.		G.	R.
		°F.	°F.		°F.	°F.		°F.	°F.
1	10.30 p. m.	78.5	78.5	9.35 p. m.	71.0	70.0	7.45 p. m.	69.1	69.3
2	.43	78.0	77.7	.39	70.8	69.9	.48	69.0	68.6
3	.49	77.4	77.8	.43	70.0	69.8	.51	69.0	68.2
4	.54	77.9	77.1	.46	69.9	69.4	.54	68.5	68.4
5	11.00	77.2	76.9	.49	69.3	69.3	.58	68.1	68.0
6	.06	77.0	76.9	.55	69.3	69.2	8.08	67.6	67.1
7	.11	77.6	77.4	.57	69.3	69.2	.10	68.0	67.7
8	.17	78.0	77.5	.59	69.0	69.0	.13	68.0	67.9
9	.22	78.5	77.9	10.02	69.3	68.8	.16	68.0	67.9
10	.26	78.1	78.6	.04	69.0	68.9	.18	68.0	68.0
11	.29	78.5	78.5	.07	68.8	68.0	.22	68.0	68.0
12	.34	78.5	78.0	.10	69.0	68.5	.24	68.0	67.3
13	.40	78.5	78.1	.13	69.0	68.4	.27	67.5	67.2
14	.47	78.3	78.2	.16	69.0	68.5	.31	67.0	67.5
15	.51	78.8	78.5	.19	69.0	68.6	.34	67.5	67.0
16	.58	78.0	78.0	.23	69.0	68.7	.36	67.0	67.0
17	0.03	78.0	77.5	.25	69.0	68.8	.39	67.0	66.3
18	0.07 a. m. (14)	77.1	77.1	.27	69.0	69.0	.42	66.9	66.2
19	.11	77.0	76.9	.30	69.2	68.7	.45	66.8	66.0
20	.15	77.0	76.9	.34	68.9	68.6	.47	66.5	66.0
21	.21	76.2	75.7	.37	69.0	68.2	.54	67.0	66.0
22	.26	75.5	76.0	.40	69.0	68.9	.57	66.9	67.0
23	.32	76.0	75.9	.43	69.0	68.4	9.00	66.5	66.2
24	.36	76.3	76.7	.52	69.5	68.7	.03	67.0	66.0
25	.42	76.0	77.0	.54	69.0	68.1	.06	66.5	65.9
26	.52	76.5	75.0	.57	68.0	67.6	.09	66.0	65.0
27	.58	76.8	75.8	11.00	68.0	67.3	.11	66.0	65.1
28	1.02	76.5	75.8	.03	68.0	67.6	.14	66.0	65.0
29	.06	76.0	75.8	.05	68.5	67.8	.17	66.3	65.4
30	.30	75.1	74.3	.11	68.4	67.8	.21	67.0	66.1
31	.35	74.0	74.1	.14	68.0	67.4	.24	67.0	66.0
32	.40	73.8	73.7	.17	67.1	67.0	.27	66.2	66.0
33	.45	73.0	72.9	.19	67.0	66.5	.29	65.9	65.4
34	.49	73.7	73.4	.21	67.0	66.4	.32	65.0	64.8
35	.57	73.5	73.8	.23	67.0	66.3	.35	65.1	65.0
36	2.04	73.2	72.8	.26	67.0	66.4	.37	65.9	65.0
36*a*	.15	72.1	72.5	.35	67.0	66.5	.41	65.5	65.0
Mean for 36 tapes		76.67	76.46	....	68.79	68.33	....	67.11	66.65
Correction		−0.97	−0.75	....	1.15	−0.87	....	−1.16	−0.80
True temperature		75.70	75.71	....	67.64	67.46	....	65.95	65.79
Reduction to 62°		13.70	13.71	....	5.64	5.46	....	3.95	3.80
36*a*		72.1	72.5	....	67.0	66.5	....	65.5	65.0
Correction		−1.10	−0.88	....	−1.16	−0.86	....	−1.19	−0.81
True temperature		71.00	71.62	....	65.84	65.64	....	64.31	64.16
Reduction to 62°		9.00	9.62	....	3.84	3.64	....	2.31	2.16

	First measurement.	Second measurement.	Third measurement.
Expansion for 36 tapes	1′.0322	0′.4184	0′.2923
Expansion for ⅛ tape	0 .0032	0 .0013	0 .0008
Total expansion	1 .0354	0 .4197	0 .2931

NOTE.—For corrections to "tape thermometer," coefficient of expansion, and modulus o ticity, see last annual report, Appendix A3.

Temperatures, Olney base—Concluded.

Number of tape.	First measurement.			Second measurement.			Third measurement.		
	Time.	Thermometers.		Time.	Thermometers.		Time.	Thermometers.	
		G.	R.		G.	R.		G.	R.
					°F.	°F.		°F.	°F.
37				11.43 p. m.	67.1	67.0	9.55 p. m.	64.9	64.4
38				.45	67.0	67.0	.58	65.0	65.0
39				.47	67.0	67.0	10.01	65.0	65.0
40				.50	67.0	66.0	.04	65.2	64.6
41				.53	66.2	66.5	.07	65.0	65.1
42				.56	66.5	66.0	.10	65.0	64.7
43				.58	66.5	65.8	.13	65.0	64.7
44				0.00	66.8	66.8	.15	65.0	65.0
45				.03 a. m. (16)	66.1	66.2	.18	65.0	64.8
46				.06	66.0	66.0	.21	65.2	65.0
47				.11	66.0	65.8	.24	65.0	65.1
48				.15	66.0	66.0	.26	65.0	65.0
49				.18	66.0	65.4	.29	64.5	64.0
50				.21	66.0	65.7	.32	64.0	63.9
51				.24	66.0	65.0	.35	64.1	63.7
52				.27	66.0	66.0	.37	64.5	63.8
53				.30	66.0	65.7	.47	64.5	64.4
54				.32	65.3	65.0	.50	65.0	64.9
55				.34	65.1	65.0	.52	65.1	65.0
56				.38	66.0	65.2	.56	65.1	65.1
57				.41	66.8	65.9	11.00	65.0	64.8
58				.45	66.1	66.3	.02	65.0	64.1
59				.55	66.0	65.0	.05	65.0	64.0
60				.59	66.5	65.5	.08	65.1	64.8
61				1.04	65.9	65.4	.11	65.6	65.1
62				.08	65.5	65.1	.14	65.1	65.1
63				.12	65.5	64.8	.17	65.0	64.5
64				.15	66.1	65.2	.20	65.0	64.7
65				.24	66.0	66.0	.23	64.9	64.9
66				.27	66.0	65.7	.27	65.0	64.5
67				.30	65.2	65.0	.30	65.0	64.9
68				.33	65.0	64.5	.32	65.5	65.0
69				.36	65.0	64.2	.35	65.9	65.0
70				.39	64.9	64.2	.39	65.0	65.0
71				.42	65.0	64.5	.42	64.5	64.9
72				.45	64.9	64.0	.46	64.0	64.1
72*a*				2.10	64.7	64.6	11.59	63.2	63.0
Mean for 72 tapes					67.38	66.95		65.95	65.67
Correction					−1.16	−0.86		−1.19	−0.84
True temperature					66.22	66.09		64.76	64.83
Reduction to 62° for 72 tapes					4.22	4.09		2.76	2.83
72*a*					64.7	64.6		63.2	63.0
Correction					−1.2	−0.8		−1.2	−0.8
True temperature					63.5	63.8		62.0	62.2
Reduction to 62° for ½ tape					1.5	1.8		0.0	0.2
Expansion for 72 tapes					0'.6258			0'.4218	
Expansion for ½ tape					0.0011			0.0001	
Total expansion					0.6269			0.4219	

First measurement: day warm, threatening a storm, no rain, no dew, calm.

Second measurement: day comparatively cool, forenoon cloudy, ground not excessively heated, night calm and clear, with very heavy dew.

Third measurement: day thickly overcast, with rain at noon, clear at night, ground not heated, calm, and heavy dew.

Correction for inclination of tape, Olney base.

Number of stake.	Elevation.	Difference of elevation.	Correction.
	Feet.	*Feet.*	*Feet.*
Δ E. B*	100.00		
Zinc Δ E. B.	105.13		
1	98.95	6.18	0.0639
2	96.05	2.90	0.0141
3	95.63	0.42	0.0003
4	95.81	0.18	0.0001
5	96.86	1.05	0.0018
6	97.11	0.25	0.0001
7	96.87	0.24	0.0001
8	96.60	0.27	0.0001
9	96.83	0.23	0.0001
10	96.60	0.23	0.0001
11	95.80	0.80	0.0011
12	95.72	0.08	0.0000
13	96.23	0.51	0.0004
14	94.27	1.96	0.0064
15	96.27	2.00	0.0067
16	96.82	0.55	0.0005
17	96.90	0.08	0.0000
18	96.55	0.35	0.0002
19	96.09	0.46	0.0003
20	96.01	0.08	0.0000
21	96.15	0.09	0.0000
22	95.96	0.19	0.0001
23	95.64	0.32	0.0002
24	95.76	0.12	0.0000
25	95.20	0.56	6.0005
26	95.17	0.03	0.0000
27	95.27	0.10	0.0000
28	93.27	2.00	0.0067
29	97.42	4.15	0.0288
30	97,09	0.33	0.0002
31	96.06	1.03	0.0018
32	97.07	1.01	0.0017
33	97.54	0.47	0.0004
34	97.23	0.31	0.0002
35	96.36	0.87	0.0013
36	97.37	1.01	0.0017
36†a	97.13	0.24	0.0006
Δ Middle base‡	92.10		
Sum for east half base			0.1405

Number of stake.	Elevation.	Difference of elevation.	Correction.
	Feet.	*Feet.*	*Feet.*
Zinc Δ E. B.			
37§	96.07	1.30	0.0028
38	97.28	1.21	0.0024
39	97.33	0.05	0.0000
40	96.46	0.87	0.0013
41	97.56	1.10	0.0020
42	98.02	0.46	0.0003
43	98.56	0.54	0.0005
44	98.77	0.21	0.0001
45	99.65	0.88	0.0013
46	100.51	0.86	0.0013
47	100.64	0.13	0.0000
48	101.20	0.56	0.0005
49	101.32	0.12	0.0000
50	101.20	0.12	0.0000
51	101.14	0.06	0.0000
52	102.76	1.62	0.0044
53	103.43	0.67	0.0008
54	104.07	0.64	0.0007
55	105.29	1.22	0.0024
56	106.64	1.32	0.0031
57	107.32	0.68	0.0008
58	108.06	0.74	0.0009
59	108.59	0.53	0.0005
60	109.70	1.11	0.0020
61	109.64	0.06	0.0000
62	109.59	0.05	0.0000
63	110.64	1.05	0.0018
64	111.10	0.46	0.0003
65	111.56	0.46	0.0003
66	111.88	0.32	0.0002
67	112.05	0.17	0.0001
68	112.30	0.25	0.0001
69	113.63	1.83	0.0030
70	115.31	1.68	0.0048
71	115.10	0.21	0.0001
72	114.37	0.73	0.0009
72‖a	113.10	1.27	0.0081
Δ W. B‡	108.09		
Total for entire base			0.1877

* Lower stone, assumed elevation.
† For 50 feet.
‡ Lower stone.
§ For 36 to 37.
‖ For 100 feet.

Measurement of the differences at end of each tape, Olney base.

Number of tape.	Third-second measurement.			Number of tape.	Third-first measurement.		
	Readings on zinc.	Correction.	Reduced.		Readings on zinc.	Correction.	Reduced.
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*
1	−0.06		−0.06	1	−0.23		−0.23
2	−0.08		−0.08	2	−0.52		−0.52
3	−0.13		−0.13	3	−0.75		−0.75
4	−0.16		−0.16	4	−0.98		−0.98
5	−0.14		−0.14	5	−1.20		−1.20
6	−0.18		−0.18	6	+2.54	−3.99	−1.45
7	−0.27		−0.27	7	+2.27		−1.72
8	−0.34		−0.31	8	+1.99		−2.00
9	−0.37		−0.37	9	+1.74		−2.28
10	−0.44		−0.44	10	+1.51		−2.48
11	−0.45		−0.45	11	+1.21		−2.78
12	−0.51		−0.51	12	+0.94		−3.05
13	−0.57		−0.57	13	+0.65		−3.34
14	−0.68		−0.68	14	+0.10		−3.89
15	−0.75		−0.73	15	+0.16		−3.83
16	−0.77		−0.77	16	−0.03		−4.02
17	−0.85		−0.85	17	−0.34		−4.33
18	−0.91		−0.91	18	−0.60		−4.59
19	−0.96		−0.96	19	−0.84		−4.83
20	−1.02		−1.02	20	−1.18		−5.17
21	+5.95	−7.00	−1.05	21	+5.70	−10.99	−5.29
22	+5.94		−1.06	22	+5.54		−5.45
23	+5.86		−1.14	23	+5.24		−5.75
24*		+1.00		24			
25	−2.36		−1.36	25	+4.68		−6.31
26	−2.32		−1.32	26	+4.50		−6.49
27	−2.31		−1.31	27	+4.26		−6.73
28	−2.32		−1.32	28	+4.05		−6.94
29	−2.51		−1.51	29	+3.83		−7.16
30	−2.53		−1.53	30	+3.49		−7.50
31	−2.57		−1.57	31	+3.33		−7.66
32	−2.60		−1.60	32	+3.15		−7.84
33	−2.62		−1.62	33	+2.95		−8.04
34	−2.66		−1.66	34	+2.75		−8.24
35	−2.71		−1.71	35	+2.47		−8.52
36	−2.77		−1.77	36	+2.34		−8.65
37	−1.81	+0.00	−1.81				
38	−1.84		−1.81				
39	−1.91		−1.91				
40	−1.96		−1.96				
41	−2.01		−2.01				
42	−2.04		−2.04				
43	−2.08		−2.08				
44	−2.09		−2.09				
45	−2.14		−2.14				
46	−2.17		−2.17				
47	−2.19		−2.19				
48	−2.24		−2.24				
49	−2.25		−2.25				
50	−2.41		−2.41				
51	−2.41		−2.41				
52	−2.45		−2.45				
53	+9.51	−12.01	−2.50				
54	+9.51		−2.50				
55	+9.52		−2.49				
56	+9.49		−2.52				
57	+9.56		−2.45				
58	+9.47		−2.54				
59	−2.56	+0.00	−2.56				
60	−2.63		−2.63				
61	−2.64		−2.64				
62	−2.66		−2.66				
63	−2.71		−2.71				
64	−2.74		−2.74				
65	−2.74		−2.74				
66	−2.57		−2.57				
67	−2.60		−2.60				
68	−2.55		−2.55				
69	−2.53		−2.53				
70	−2.50		−2.50				
71	−2.49		−2.49				
72	−2.49		−2.49				

* Zinc No. 24 disturbed.

REMARKS.

Amounts set ahead:

Inches.

3.99 on zinc No. 5, second measurement.
3.99 on zinc No. 5, third measurement.
7.00 on zinc No. 20, third measurement.
8.00 on zinc No. 23, second measurement.
10.01 on zinc No. 36, second measurement.
11.01 on zinc No. 36, third measurement.
12.01 on zinc No. 52, third measurement.
12.01 on zinc No. 58, second measurement.

Total for entire base:

	Inches.	Feet.
Second measurement	=34.01	=2.8342.
Third measurement	=34.01	=2.8342.

Total for east half:

Second measurement	=11.99	=0.9992.
Third measurement	=10.99	=0.9158.

36 to 36a = +50 feet of tape.
36a to 36b = +4.3700 feet, first measurement.
36a to 36b = +3.9458 feet, second measurement.
36a to 36b = +4.1734 feet, third measurement.
36b is over △ middle base.
72 to 72a = +100 feet of tape.
72a to 72c = −13.0634 feet, second measurement.
72a to 72c = −12.8545 feet, third measurement.
72c is over △ west base.

The following table, from data given in tables in the last annual report (see Appendix A3f), shows with what accuracy it is possible to measure with the steel tape, and is about the average accuracy obtained in the secondary base measurements on the triangulation of the Missouri River:

Number of zinc.	Readings from zincs.	Individual differences from two measurements.	Corresponding differences in temperature.	Correction for expansion.	Individual differences corrected for expansion $=d$.	$d\,d$.
	Inches.	*Inches.*	°	*Inches.*	*Inches.*	
0	+0.00					
1	+0.02	+0.02	−0.5	+0.01	+0.03	0.0009
2	+0.04	+0.02	−0.5	+0.01	+0.03	9
3	+0.05	+0.01	−0.7	+0.02	+0.03	9
4	+0.06	+0.01	−1.5	+0.04	+0.05	25
5	+0.03	−0.03	−2.0	+0.05	+0.02	4
6	+0.01	−0.02	−2.5	+0.06	+0.04	16
7	−0.14	−0.15	−2.7	+0.07	−0.08	64
8	−0.20	−0.06	−3.0	+0.07	+0.01	1
9	−0.29	−0.09	−3.1	+0.08	−0.01	1
10	−0.39	−0.10	−2.9	+0.07	−0.03	9
11	−0.49	−0.10	−3.2	+0.08	−0.02	4
12	−0.58	−0.09	−3.2	+0.08	−0.01	1
13	−0.68	−0.10	−2.6	+0.07	−0.03	9
14	−0.78	−0.10	−3.1	+0.08	−0.02	4
15	−0.85	−0.07	−1.0	+0.02	−0.05	25
16	−0.92	−0.07	−1.0	+0.03	−0.04	16
17	−1.00	−0.08	−1.9	+0.05	−0.03	9
18	−1.10	−0.10	−2.0	+0.05	−0.05	25
19	−1.13	−0.03	−1.7	+0.04	+0.01	1
20	−1.21	−0.11	−1.6	+0.04	−0.07	49
21	−1.28	−0.04	−1.7	+0.04	±0.00	0
22	−1.32	−0.04	−1.3	+0.03	−0.01	1
23	−1.34	−0.02	−1.1	+0.03	+0.01	1
24	−1.27	+0.07	−0.4	+0.01	+0.08	64
25	−1.28	−0.01	−1.0	+0.02	+0.01	1
26	−1.31	−0.03	−1.0	+0.03	±0.00	0
27	−1.31	±0.00	−0.9	+0.02	+0.02	4
28	−1.33	−0.02	−1.3	+0.03	+0.01	1
29	−1.27	+0.06	−0.3	+0.01	+0.07	49
30	−1.30	−0.03	−0.7	+0.02	−0.01	1
31	−1.33	−0.03	−0.6	+0.02	−0.01	1
32	−1.32	+0.01	−1.1	+0.03	+0.04	16
33	−1.41	−0.09	−2.0	+0.05	−0.04	16
34	−1.49	−0.08	−2.9	+0.07	−0.01	1
35	−1.53	−0.04	−3.0	+0.07	+0.03	9
36	−1.59	−0.06	−2.5	+0.06	±0.00	0
						$\Sigma\,d\,d=0.0455$

The second column contains accumulative differences in the two measurements, due to incidental errors and to expansion in tape, from which, if a difference of temperature correction be taken, it is then possible to compute a probable error for one tape measurement, and, since the base is known, also to compute a probable error for the value of one tape length. The expansion for 1 tape for one degree = 0.025 inch.

The two measurements of the east half of the Olney base (Primary, 1879) were made on October 28, 1885. The entire day was overcast, with a very light mist falling. Wind northeast, almost a calm.

Considering the measurements as in 36 independent sections, the probable error in the mean of the two measures for 36 tapes distance is:

$$0.6745\sqrt{\frac{\Sigma\,d\,d}{4}} = \pm\ 0.0719 \text{ inch.}$$

(See Professional Papers, Corps of Engineers, U. S. Army, No. 24, pages 287, 303, and 304.) The probable error of the east half of the Olney base, computed by the method there given and not reduced to sea level, is $= \pm\ 3.215^{mm} = \pm\ 0.127$ inch. Combining these two we have—

$$\sqrt{(0.0719)^2 + (0.127)^2} = \pm\ 0.146 \text{ inch;}$$

and this divided by 36 gives the probable error of the tape-length determination $= \pm\ 0.004$ inch, or one in 897,237 parts of the tape length.

There are two other methods by which the probable error might have been computed, but in each there is the objection that they are primarily computed from too few observations.

The difference in the two measurements shown on zinc No. 36 is 1.59 inches.

The mean temperatures during first and second measurements are, respectively, 55°.54 Fahr. and 53°.83, giving a difference of 1°.71, and the expansion due to this difference = 1.55 inches.

This difference in the two measurements is then 0.04 inch, and this gives a probable error of ± 0.013 inch for the mean.

From column *d* 36 values for the probable error of one tape measurement may be found, and these combined and the result multiplied by $\sqrt{36}$ gives ± 0.012 inch for the mean of the two measurements. These are many times less than that first found—namely, ± 0.0719 inch—but are not as satisfactory.

APPENDIX A A A.

CONSTRUCTION AND IMPROVEMENT OF ROADS AND BRIDGES IN THE YELLOWSTONE NATIONAL PARK.

ANNUAL REPORT OF CAPTAIN CLINTON B. SEARS, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

UNITED STATES ENGINEER OFFICE,
Bismarck, Dak., July 20, 1887.

SIR: I have the honor to transmit herewith my annual report, in duplicate, upon the improvement and construction of roads and bridges in the Yellowstone National Park for the fiscal year ending June 30, 1887.

I remain, general, very respectfully, your obedient servant,

CLINTON B. SEARS,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

CONSTRUCTION AND IMPROVEMENT OF ROADS AND BRIDGES IN THE YELLOWSTONE NATIONAL PARK.

[In charge of Capt. Dan C. Kingman, Corps of Engineers, until April 1, 1887.]

As the principal construction work of the year was carried on from July 1, 1886, to October 15, 1886, under the direction of my predecessor, Capt. Dan C. Kingman, Corps of Engineers, and as Captain Kingman has done a good deal of excellent work with very limited means, it is due to him that a memorandum report, kindly prepared by him for my information, be essentially embodied in this report. Also, that Congress may have before it a historical résumé of the previous operations in connection with the construction and improvement of roads and bridges, I quote extensively from Captain Kingman's notes on this point.

Captain Kingman says:

An act of Congress, approved March 3, 1883, appropriated $40,000 for every purpose and object necessary for the protection, preservation, and improvement of the Yellowstone National Park, including compensation of the superintendent and his assistants. The salaries of these persons were fixed by the act, and amounted in the aggregate to $11,000. The act provided that the balance of the appropriation should be expended in the construction and improvement of suitable roads and bridges within said park, under the supervision and direction of an engineer officer detailed by the Secretary of War.

This was the beginning of systematic road construction in the Park. Prior to that Congress had made a number of small appropriations for the protection and im-

provement of the Park, and a portion of this money has been expended by the different superintendents in opening roads and trails. These roads and trails made it possible to reach the various points of interest in the Park, but the work done was temporary and the locations were faulty, and thus were of little or no value in the general plan of permanent improvement.

In July, 1883, I was designated by the Secretary of War to carry out the provisions of the act before referred to, and I went to the National Park. I found the following roads in existence then:

A road from the western boundary to the Forks of the Fire Hole River, about 20 miles in length.

A road from the last-named point to Mammoth Hot Springs, about 40 miles.

A road from Mammoth Hot Springs to the mouth of the Gardiner River, about 4 miles.

A road from Mammoth Hot Springs eastward *via* Baronett's Bridge towards Clark's Fork Mines, about 50 miles.

A road from the Forks of the Fire Hole River to the Upper Geyser Basin, about 10 miles.

A road from the same point to the Falls of the Yellowstone River, about 28 miles.

A branch from this road to the outlet of the Yellowstone Lake, about 8 miles.

In all about 160 miles of road, over which one could pass with a wagon under favorable circumstances with more or less difficulty.

In addition to this there were many miles of blazed trails, passable on horseback.

The roads, however, were all very bad—barely passable even in good weather. The lack of means and the desire to reach in some way the various points of interest had forced those in charge to be guided in their location by the question of first cost. Very crooked as well as very hilly roads were the result. In general, only trees enough have been cut down to permit the passage of a single wagon, and the stumps were left standing well above ground.

For miles the roads were so narrow that teams meeting had great difficulty in passing, and an outrider was a necessary adjunct of a train. Such bridges as had been constructed were covered with small poles, and there were long stretches of badly built corduroy that were almost impassable when wet.

The side-hill cuttings were generally supported on the outside by small logs and brush, and were necessarily very temporary in character. No attention had been paid to drainage, and the water ran in the middle of the roads, or stood in pools in the low places.

The principal points of interest, and those which the public were most anxious to visit, were: The Mammoth Hot Springs, the Norris Geysers, the Lower Geysers (at the Forks of the Fire Hole River), the Upper Geysers, the Yellowstone Lake, and the Falls and Grand cañon of the Yellowstone River, and it will be seen that the existing roads enabled the tourist to visit them all.

The approaches are, first: *Via* the Northern Pacific Railroad to Livingston, Mont.; thence by the Park Branch Railroad to Cinnabar, Mont., from which it was about 8 miles to Mammoth Hot Springs. And second: *Via* the Utah and Northern Railroad to Beaver Cañon, Idaho; thence by stage up the valley of the Madison River to the Fire Hole Basin, about 100 miles. By far the greater number of travelers chose the former route.

Such was the condition of affairs at the time of my arrival in the Park.

The project that I have prepared for the improvement of the Park called for the construction of the following roads:

	Miles.
A road from Mammoth Hot Springs to the boundary of the Park toward the terminus of the Park Branch of the Northern Pacific Railroad (about)	5
A road from Mammoth Hot Springs to the Fire Hole Basin (about)	40
A road from the Fire Hole Basin to the Upper Geyser Basin (about)	10
A road from the Fire Hole Basin to the Cañon and Falls of the Yellowstone River (about)	28
A branch from this road to the outlet of the Yellowstone Lake (about)	8
A road from Mammoth Hot Springs to Yancy's (about)	18
A road from the Yellowstone Falls over the shoulder of Mount Washburn to Yancy's (about)	20
A road from the Upper Geyser Basin *via* Shoshone Lake and the thumb of the Yellowstone Lake to the outlet (about)	40
A road from Norris Geysers eastward to connect with the road to the Yellowstone Falls (about)	9
A road from the Fire Hole Basin westward *via* the Madison Cañon to the boundary of the Park (about)	20
A road from Yancy's *via* Soda Butte to the boundary of the Park toward the Clark's Fork Mines (about)	35
In all (about)	223

* * * * * * *

The foregoing system of roads, if constructed, would enable tourists to visit the principal points of interest in the Park without retracing their steps; and to take a long or short trip, according to the time and means at their disposal.

The route from Mammoth Hot Springs through the Norris Geysers to the Lower and Upper Geyser Basins, thence to Shoshone Lake, thence to the Yellowstone Lake, and along the lake to the outlet, thence down the river past the Mud Geysers to the Falls, thence along the brink of the Cañon, and over the shoulder of Washburn to Tower Creek and Falls and to Yancy's, and thence back to the springs, would enable persons, without retracing their steps, to visit all the principal points of interest, and would be a journey of about 150 miles.

By not visiting the lakes and going from the geysers to the falls the journey would be reduced to 125 miles, and by going from the Norris Geysers to the falls the trip would be but 80 miles.

* * * * * * *

The region embraced by the Yellowstone Park, from its high, rugged, and mountainous character, presents in varied forms and combinations almost every obstacle that nature offers to the construction of roads. There are steep mountains, dense forests, rocks, streams, cañons, and marshes, heavy rains, deep snows, besides the peculiar hot springs formations, which are very extensive, and afford the worst road material I have ever met with.

I recommended that no more bad roads be built in the Park, but that thereafter they have something of the solid, durable, and substantial quality that usually characterizes the works constructed by the Government.

I therefore proposed that all roads in the National Park should be made at least 18 feet wide and well-rounded up in the center, and provided with suitable side ditches and cross-culverts; that all trees be removed for a width of 30 feet; and on side-hill cuttings the fill to be retained by a dry stone wall, and that an ample ditch be placed on the uphill side to catch the snow-water and carry it to the natural water-courses; that all culverts be of stone or 3-inch plank; and that all bridges be well constructed of sawed lumber.

After carefully examining the country through which the roads would have to pass, I was satisfied that suitable ones could not be built for a less average cost than $1,000 per mile, nor properly maintained for a less annual outlay than 10 per cent. of the first cost. In the execution of the project it was proposed to make such repairs to the existing roads as would enable them to be used till the new ones could be built; then, as the amount appropriated was very small, in comparison with the estimated cost, it was proposed to expend it on such parts of the new system of roads as would be of most direct and immediate benefit to travelers in the Park. The work was all done by hired labor, and the supplies were purchased in open market. The repairs above mentioned consisted in widening and straightening the roads, removing stones, stumps, and trees, improving the drainage, constructing turn-outs at frequent intervals, reducing slopes, repairing bridges and fords, covering corduroy with sods and earth, etc., and the cost was from $25 to $175 per mile. The roads were much improved; but they were very far from being good, even then.

In the meantime I commenced a new road from Mammoth Hot Springs to and through the cañon of the west fork of the Gardiner River, to connect with the road of the Fire Hole, at a point near Swan Lake.

At the end of the working season of 1883, I estimated that it would require $205,000 to complete the project; of this amount, $6,000 was for office and quarters; $20,000 for the road from Yancy's to Clark's Fork; * * * thus leaving $179,000 as the amount necessary for completion of the system of roads that now form the project.

The superintendent of the Park was authorized by the Secretary of the Interior to expend such portion of the appropriation as might be necessary for the protection and preservation of the Park. This reduced the amount available for roads and bridges from $29,000 to $23,570.03.

The total amount that has been expended upon this work, up to the beginning of the present fiscal year, is as follows:

Appropriation of 1883	$23,570.03
Appropriation of 1884	23,000.02
Appropriation of 1885	23,209.37
Total to June 30, 1886	69,779.42

The following is a summary of expenditures:

New work	40,982.43
Annual repairs	12,697.28
Tents, tools, and materials (including steam saw-mill)	5,898.01
Clerical labor	2,269.00
Railroad traveling expenses	1,737.00

Watchmen (during winter months)	$1,191.54
Manufacture of lumber	1,949.54
Expenses incident to exploration and survey, and the general supervision of the work	1,915.11
Repair of tools, hauling freight, express, telegraph, etc	1,140.00
Total to June 30, 1886	69,779.91

The new work referred to is as follows:

	Miles.
(1) A road from Mammoth Hot Springs to Gardiner, Mont. (about)	5
(2) A road from Mammoth Hot Springs to Swan Lake (about)	5
(3) A road from Beaver Lake to the Norris Geysers Hotel (about)	7
(4) A road from the hotel at the Fire Hole to the Castle Geysers, Upper Basin (about)	9
(5) A road through the Gibbon Cañon (about)	3
(6) A road along the Yellowstone River near the falls (about)	1.5
In all (about)	30.5

The first was begun in the summer of 1884, and was completed August 18, 1885. This is the route followed in going from the Park to the terminus of the Northern Pacific Railroad, and is used as a freight road, as well as for the transportation of passengers. It is used by the superintendent of the Park and his assistants, and other residents of Mammoth Hot Springs, during the entire year. They receive their mail and supplies over it, and therefore, unlike most of the roads in the Park, it must be practicable at all times; in other words, it must be a winter as well as a summer road.

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The total cost of the work was $7,750.52.

The second piece of new work (Mammoth Hot Springs to Swan Lake) was commenced in September, 1883, and finished June 12, 1885. This road was intended to avoid the worst obstacle to the entrance to the Park from the north, which was the steep hill which must be ascended in order to reach the plateau lying south of Mammoth Hot Springs, and commanding the site of the hotel some 1,200 feet. This ascent was overcome by the old road in about 2 miles, and not by a uniform grade either, but by a series of inclines so steep as to be almost impassable for a loaded wagon when the ground was wet, and dangerous to descend at all times. The new road follows up the west fork of the Gardiner River, and unites with the old one about 5 miles from the starting-point. This route, though heavily timbered, and covered in many places with rocks and bowlders, offered no serious obstacle to the construction of a road until the head of the Cañon was reached. Here, for about 1,000 feet, the rock walls approached each other, and were nearly vertical, and the little stream in the cañon had a fall of 60 feet. The walls were too high to admit of the road being carried over the top. This quarter of a mile was by far the most difficult and expensive piece of work undertaken in the Park.

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At the mouth of the cañon the wall was nearly vertical, and sufficient roadway could be secured only by cutting and breaking down the solid rock over 100 feet. The cost of this would have been excessive. The road in this portion was supported by timber trestles.

* * * * * * *

The total length of the structure is 224 feet, and its cost was $3 per running foot. When the rock walls were sufficiently inclined the road was built entirely in excavation. At some points it was necessary to begin work 70 feet above the proposed road-bed.

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The excavation of this work required the removal of over 14,000 cubic yards of solid rock, besides a very large amount of rock in a crushed and broken condition. Twelve hundred and seventy-five pounds of explosive (one-half of which was dynamite) was used in the work, and nearly 1,300 shots in drilled holes were fired. The work was accomplished without accident or injury to any one. The benefits conferred by this improvement are very marked. The distance from Mammoth Hot Springs to the Geysers and other points of interest is reduced 1½ miles, and the height to be overcome in reaching the Swan Lake Plateau is reduced 250 feet. The ascent is made so gradually that loaded teams pass over the road in both directions with ease and safety, and the time required to go from Mammoth Hot Springs to points within the Park has been shortened by the improvement alone from two hours to a half a day, depending upon the team and its load. The total cost was $14,395.39.

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The third new work is the road from the south end of Beaver Lake to the hotel at Norris Geysers Basin. It was begun and finished in the summer of 1885. The object of this road was to avoid a series of obstacles due to bad location.

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The new location follows a lower level, giving drainage, exposure to the sun, and a soil more suitable for road covering. The total length of the section is 7 miles, and its cost of construction was $6,269.80, or about $993.62 per mile, including wear of tools, office expenses, etc.

The fourth improvement (Fire Hole to Upper Basin). This road was completed in one season (1885). Its length is 8.9 miles, and its cost was $6,042.53. It reduces considerably the distance to be traveled in reaching the Upper Geyser Basin. It is well built throughout, and its bridges and culverts are of the most substantial character. It follows the river, and is sensibly level, and as the road-bed is mostly composed of gravel that packs well, it is a very pleasant road to drive over.

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The fifth new road (through Gibbon Cañon) was commenced in the summer of 1884 and completed August 1, 1885. This section, about 3 miles in length, was generally one of the worst in the Park, and was dreaded alike by drivers and tourists. It is now a good road at all times, is never muddy, and forms a stretch that drivers soon select to make up lost time on. Its total cost was $4,604.64, including a very good bridge that cost $877.

The sixth section was along the Yellowstone River, near the Falls. The improvement was made in the summer of 1884 and cost $1,919.57.

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This was the condition of affairs at the beginning of the present fiscal year. Up to this time the funds for the work had been disbursed by the superintendent of the Park on my vouchers duly certified. The appropriation for the fiscal year ending June 30, 1887, amounted to $20,000, and it was provided in the act that this money should be expended under the direction of the Secretary of War.

The project for its expenditure was as follows: First, to build a wagon-road from Norris Geysers to Grand Cañon, 12 miles, cost $12,000; Second, general repairs to existing roads, $8,000.

Work was pushed vigorously on the new road, but owing to early snow-storms and bad weather it was not completed. Its total length is 11½ miles. All of the trees, stumps, and rocks have been removed from the right of way, and about 9 miles have been graded. The amount expended on this work is $9,368.48, and I estimate that it will require about $3,000 to complete the work. About $1,000 of this will be needed for the repair of the portion graded last fall, for, being soft, it will probably be washed a good deal. I also made thorough repairs (amounting to rebuilding) to the section of road from Green Creek along Beaver Lake and Obsidian Cliff. The work was expensive on account of the number of rock cuts, and it is very well done. The right of way is cleared for about 2½ miles and it is graded and finished for about 1½ miles. A very good bridge was built across the outlet of Beaver Lake. The cost of the improvement was $4,431.49. In addition the sum of $138.50 was expended in minor repairs elsewhere.

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By direction of the Chief of Engineers I submitted an estimate October 9, 1886, as follows:

ESTIMATE FOR ROADS IN YELLOWSTONE PARK, FOR FISCAL YEAR ENDING JUNE 30, 1888.

For road from Upper Geysers to outlet of lake, via the west arm	$40,000
From outlet to Yancy's via Grand Cañon	45,000
From Yancy's to Mammoth Hot Springs	20,000
For road from Fire Hole to boundary of Park towards Beaver Cañon	20,000
For general repair and improvement of existing roads	25,000
Total	150,000

This will build 100 miles of new road and repair 100 miles.

In the foregoing I made no estimate for the road from Yancy's to the boundary of the Park towards the Clark's Fork mines. This item has been omitted from the estimate since the first year of the work. About this time an effort was made to secure from Congress a right of way for a railroad through the Park to reach these mines. If this railroad was built there would certainly be no need of a wagon-road. Fortunately this bill failed each year to become a law, and now another route, that does not pass through the Park, has been found, and the matter may be regarded as settled.

I think, however, that a road should some time be built as far as Soda Butte. This is a very beautiful and interesting portion of the Park, and Soda Butte ought always to be kept up as a game-keeper's station. In regard to railroads, I need only say that I should regard their introduction into the Park, upon any pretext whatever, as a very serious detriment and injury, and I think that all true friends of the Park should oppose them by every means in their power.

Captain Kingman turned over to me an unexpended balance of $3,547.58. After the close of work in the fall of 1886 all employés, except a watchmen, were discharged, and the tools and plant were stored in a rough shed, loaned by the Interior Department.

In May, 1887, I visited the Park and made arrangements for the early resumption of the repair work, to be paid for out of the above unexpended balance.

I arranged the working party so as to make the money carry on work to July 1, thus preserving an efficient skeleton organization for the work of the next fiscal year under a new appropriation.

The winter of 1886-'87 was a long and severe one, attended with a heavy fall of snow. This had its effect on the roads in the Park, and it required more than the above balance to put them in good shape for the summer's travel. It was expended, however, as judiciously as possible, and by June 20 the permanent roads were all in very fair condition.

The Gardiner River, having changed its channel just above the main bridge, threatened the undermining of the south abutment pier. A brush and gravel dam and revetment were built, to turn the water back into the old channel, so as to pass the current under the bridge parallel to the piers. This work was well done, under the supervision of my overseer, Mr. Lamartine, and has fully accomplished its purpose, and undoubtedly saved the bridge, as the spring rise in the Gardiner was unusually high and long maintained.

On the 16th of May two parties with teams and scrapers were set to work on general repairs, which consisted in cleaning out ditches and culverts, filling ruts, crowning up roads, replanking lower bridge over Gardiner River, rebuilding retaining-walls, where injured by spring storms, and clearing off fallen timber and rocks, earth, sand, etc., washed down by snow slides, spring thaws, etc.

About half a mile of the road alongside and in the bed of the Virginia Cañon had been washed out by the spring floods in the Gibbon River, requiring an entirely new construction.

The high trestle bridge in the Golden Gate Cañon (Kingman Pass) was strengthened by putting in another heavy timber support and road-bearer cross-beam, the new bent being well braced to those on each side. A rough temporary bridge of logs and poles was built across Obsidian Creek, which had been unusually high, making the ford dangerous, to accommodate travel until a permanent bridge could be built. A number of small bridges, damaged by spring storms, were repaired.

On June 30, 1887, therefore, the permanent roads and bridges were in good order, the old temporary roads were in fair condition, and all of the appropriation for the fiscal year was exhausted.

Congress, by act approved March 3, 1887, appropriated $20,000 for the fiscal year ending June 30, 1888. It is proposed to retain about $3,000 of this for necessary repairs next spring, before a new appropriation, if made, becomes available, and to expend the balance this summer and fall:

(1) In finishing the present incompleted road from Norris Basin to the Grand Cañon of the Yellowstone, about 12 miles.

(2) To build a new road from Swan Lake Meadow to Beaver Lake, to fill the gap in the main road from Mammoth Hot Springs to Norris Basin. This will be about 7 miles in length.

(3) To build 6 miles of new road from Norris Basin to Gibbon Cañon, closing this gap in the main highway into the Park.

(4) To build about 10 miles of new road from Gibbon Cañon to Fire Hole Basin, or as much thereof as the remaining funds will permit.

A few light trails will be cut out to objects of special interest, such as the top of the Great Falls of the Yellowstone, and perhaps a foot-bridge will be thrown across the river just above the Upper Falls.

My policy will be that of my predecessor, Captain Kingman, to build thoroughly good roads and bridges, as far as we go, rather than to attempt to secure a greater mileage of inferior roads.

Captain Kingman, in his previous annual reports, has strongly urged on Congress the advisability of giving more liberal appropriations for the improvement of the artificial features of the great National Park. I quote as follows from his reports:

It is very difficult to make plans for the improvement of the Park, on account of the uncertainty as to what its future is to be.

The law says that it is dedicated and set apart as a public park or pleasuring ground, for the benefit and enjoyment of the people. As long as its timber is preserved it is valuable as a reservoir for our two great rivers. If it were extended, so as to include winter as well as summer ranges, it might also afford a last resort and permanent abiding place for the large game of the country.

The plan for improvement which I have submitted is given upon the supposition, and in the earnest hope, that it will be preserved as nearly as may be as the hand of nature left it—a source of pleasure to all who visit it, and a source of wealth to no one. If the Park ever becomes truly popular and national, it will be when the people come to know and appreciate its delightful summer climate, the wonderful efficacy of its baths and its mineral waters, as well as the natural wonders, beauties, and curiosities to be seen there; then, if there are numerous small, quiet hotels scattered here and there throughout the Park, where visitors can have plain and simple accommodations, at moderate prices, the overworked and the sick, as well as the curious, will come here, not to be awed by the great fall and astounded by the geysers, and then to go away, but will come here and remain for weeks or months, and will find what they seek—rest, recreation, and health. But if it ever becomes the resort of fashion, if its forests are stripped to rear mammoth hotels; if the race-course, the drinking saloon, and the gambling-table invade it; if its valleys are scarred by railroads and its hills pierced by tunnels, if its purity and quiet are destroyed and broken by the noise and smoke of the locomotive; if, in short, a sort of Coney Island is established there, then it will cease to belong to the whole people and will be unworthy the care and protection of the National Government.

* * * * * * *

During the past season (1885) the game, the growing timber, and the objects of curiosity and interest in the Park have been better protected than ever before; the number of visitors increases from year to year, and while there are many complaints of bad roads, poor and inadequate hotel accommodations, and high prices, I talked with none among the thousands who visited it who did not appreciate the wisdom that dedicated the National Park to its present uses, or who doubted that the Park was destined to a great and valuable future. It is not too much to say, that if the Park can be preserved as it now is, subject only to such slight changes as are necessary to secure good roads and trails through it, and proper hotels to insure the comfort of visitors, it will become, in time, a health and pleasure resort unequalled in the whole world. Its maintenance is of more than national importance; it is an object of direct personal interest, now and in time to come, to travelers and scientists the world over.

I can not too heartily indorse what Captain Kingman says. The National Park is a great national trust, which should be carefully guarded and preserved, while, at the same time, made readily, safely, and cheaply accessible throughout its extent.

In addition to the main thoroughfares, good branch roads and trails should be made to the many minor objects of interest off the main lines of travel. About and across the hot spring and geyser formations good walks should be laid for their protection, and for the comfort and safety of tourists.

As the mileage of permanent roads increases the outlay for annual repairs will become greater. Under the present system of small annual appropriations, the repair and maintenance allotment is unduly large compared with the construction expenditure, being about 17 per cent., when it should be not more than 10 per cent. It would be much better to appropriate each year, for a few years, as large amounts as can be properly expended each season, until all the roads and bridges are in first-class shape; after that it would need very small annual appropriations for repairs and maintenance. The homely proverb, "A stitch in time saves nine," is nowhere so applicable as to roads. Timely repairs are the most economical in the long run, and for this reason a considerable percentage of the small annual appropriations is reserved for spring repairs.

All roads in the Park should be equal to the best macadamized country roads anywhere extant in the United States. Every dollar properly and economically expended on the roads and bridges is put where it will show for itself in direct benefits to be derived, and such improvement adds to the material and constructive value of this fine national domain, just as ditches, fences, trees, buildings, etc., add to the value of agricultural lands or other real estate.

Captain Kingman estimated for the fiscal year ending June 30, 1888, $150,000, while only $20,000 was granted. I renew his estimate, less the $20,000 given, making $130,000 for the fiscal year ending June 30, 1889, and strongly recommend that this amount be appropriated, and be made available upon the passage of the act. The working season after July 1 is very short, and it would be of material advantage to have a good sum available early in the spring, or not later than May 15, 1889.

With this estimated amount it is proposed to accomplish the following, viz:

To build a road from Upper Geyser Basin over the Continental Divide to the mouth of the Yellowstone River, via the west arm of the lake, 30 miles ..	$40,000
To improve and complete the present rough road from the lake along the river to the Grand Cañon, 14 miles	10,000
To build a new road from the Grand Cañon to Yancy's, 20 miles	30,000
To improve and complete the present rough road from Yancy's to the Mammoth Hot Springs, 18 miles	20,000
(Thus completing the circuit of the park, and obviating for tourists the necessity of having to retrace any roads.)	
For general repairs of existing roads	20,000
For a portable steam saw-mill	3,000
For a portable rock-crusher	2,000
For warehouse, stable, office, and dwelling-house for overseer and watchman	5,000
Total	130,000

Hauling lumber for bridges is, at present, a great item of expense; good milling trees are abundant in the vicinity of all bridge sites, and it would be more economical to have a portable steam saw-mill that could be placed to saw lumber on the site needed than to haul from the present saw-mill at Mammoth Hot Springs. There is plenty of good rock for road covering in the park, and it is widely distributed. A good steam rock-crusher is needed to reduce this rock to the proper shape and dimensions.

A suitable warehouse for the winter storage of tools and outfit, and for a summer depot for subsistence supplies, is much needed, as is also a small warm stable for the housing of such stock as may be needed by the permanent repair party. A portion of the warehouse could be set off and used as an office for the resident engineer and overseer.

A plain, comfortable residence for the latter should be provided. This can be used in winter by the watchman in charge of the property and plant belonging to the work. There are no houses to be rented and in winter the hotels are closed, so that the watchman has no place to live. He should be furnished every reasonable comfort, including a place for his family, as the winters are long and severe, and he is almost entirely isolated from the world.

It will always be necessary to keep some one in the Park to have charge of the annual repairs, so that the expenditure for buildings, as recommended above, will be judicious and necessary. These buildings should be situated at Mammoth Hot Springs, the headquarters of the superintendent and other Park officials. The saw-mill is there, and trees for milling abound in the neighborhood. The lumber will be relatively cheap, and strong, warm, substantial buildings can be erected for the sum estimated. Once built, they will last for very many years.

In conclusion, I desire to acknowledge the material and valuable assistance I have received from my overseer, Mr. Lamartine. He has been devoted to his duties, and has performed them intelligently and faithfully.

Money statement.

Amount appropriated by act approved August 4, 1886	$20,000.00
July 1, 1887, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1886	20,000.00
Amount (estimated) required for completion of existing projects	250,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1889	130,000.00
Total expended to July 1, 1887	89,779.42

APPENDIX B B B.

ISSUE OF PUBLISHED CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES.

ANNUAL REPORT OF LIEUTENANT-COLONEL O. M. POE, CORPS OF ENGINEERS, BVT. BRIG. GEN., U. S. A., FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 7, 1887.

SIR: I have the honor to transmit herewith, in duplicate, my annual report on the "issue of the published charts of the Northern and Northwestern lakes" for the fiscal year ending June 30, 1887.

Very respectfully, your obedient servant,

O. M. POE,
Lieut. Col. of Engineers,
Bvt. Brig. Genl., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

The issue of the charts to registered vessels has continued during the year in accordance with regulations; also their sale at a fixed price (to cover cost of paper and printing) to all who desired to purchase.

The following table shows the extent of this business:

Table showing the issue of charts of the Northern and Northwestern lakes during the fiscal year ending June 30, 1887.

Description.	Number.	Total.
Charts on hand July 1, 1886	5,109	
Charts received during the year	5,230	10,339
Charts issued to vessels, etc	4,995	
Charts sold, at 30 cents each	1,536	6,531
Charts on hand July 1, 1887		3,808

The sum of $460.80 was turned into the Treasury from sale of 1,536 charts, at 30 cents each.

Total number of charts issued to July 1, 1886	142,300
Issued between July 1, 1886, and July 1, 1887	6,531
Total issue to July 1, 1887	148,831

Owing to changes in channels, the discovery of previously unknown dangers, and the extension of works of river and harbor improvement, many of the charts now require additions and corrections in order to render them of the greatest service. In some cases limited surveys will be required to obtain the requisite data. A case in point is the shoal some 2 miles west-southwest from Waugoshance light-house. The shoalest sounding in this vicinity shown on the chart is 22 feet, yet a steamer has been aground this season only a short distance from it in 14 feet of water. This shoal should be surveyed and located on the charts, but there are no funds available for the purpose.

Considering the extensive use made of the charts, and their recognized value to the lake marine, the sum of $10,000 should be annually appropriated for the purpose indicated, and I urgently recommend that a beginning be now made in the matter. The cost of printing and issuing charts is now so small that it can not be further reduced.

I therefore have the honor to submit the following:

ESTIMATE FOR THE FISCAL YEAR ENDING JUNE 30, 1889.

For printing and issuing charts for the use of navigators, and electrotyping copper plates for chart printing	$3,000
For minor surveys and other expenses connected with correcting and extending the charts of the Northern and Northwestern lakes	10,000
Total	13,000

Money statement.

SURVEYS OF NORTHERN AND NORTHWESTERN LAKES 1887.

Amount allotted from act approved August 4, 1886		$1,000
July 1, 1887, amount expended during fiscal year		1,000
July 1, 1887, amount available, appropriation March 3, 1887 (allotment for this office not yet made)		2,000
Amount required for continuing printing and issuing charts	$3,000	
Amount required for minor surveys, etc	10,000	
		13,000

APPENDIX C C C.

EXPLORATIONS AND SURVEYS IN THE DIVISION OF THE MISSOURI.

ANNUAL REPORT OF MAJOR THOMAS H. HANDBURY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

HEADQUARTERS DIVISION OF THE MISSOURI,
OFFICE CHIEF ENGINEER,
Chicago, Ill., July 8, 1887.

GENERAL: I have the honor to submit the following report of the operations carried on from this office during the fiscal year ending June 30, 1887.

There has been no field work in progress during the year. The office force has consisted of one general service clerk, Frederick A. Petersen. The office work has consisted in collecting, compiling, and platting geographical information for the improvement of existing maps; in making reductions and enlargements, and fac simile copies and tracings of maps of military and Indian reservations, posts, scouts, reconnaissances, etc., for use at these headquarters, for file and forwarding.

During the year monthly reports of operations have been received from the engineer officers of the departments included in this division. Besides these reports these officers are required to forward such special reports and maps of work done as may be useful to the major-general commanding the division.

* * * * * * *

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major Corps of Engineers,
Engineer Officer, Division of Missouri.

Brig. Gen. JAMES C. DUANE,
Chief of Engineers, U. S. A.

NOTE.—SUMMARY OF OFFICE WORK PERFORMED DURING THE YEAR.

Map (territory west of the Mississippi River) corrected by hand	1
Maps mounted	21
Maps issued	44
Tracings made pertaining to railroads, military reservations, rifle ranges, etc	33
Blue prints made pertaining to the proposed military post at Highwood, Ill., and to the reservation at Fort Winnebago, Wis	34
Sundry sketches of flags and relating to target practice.	

APPENDIX D D D.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF CALIFORNIA.

ANNUAL REPORT OF LIEUTENANT THOMAS L. CASEY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

ENGINEER OFFICE,
HEADQUARTERS DIVISION OF THE PACIFIC,
San Francisco, Cal., July 11, 1887.

SIR: I have the honor to transmit herewith my report of operations in this office for the fiscal year ending June 30, 1887.

Topographical Assistant Clement Winstanley has been continually on duty throughout the year and has rendered valuable and very efficient service. Assistant H. H. Price, previously on duty in this office, went out of service on the 30th of June, 1886, in accordance with an order reducing the clerical force of the division.

But little field-work has been accomplished because of the lack of the necessary funds, and this has been limited to several small surveys in the neighborhood of the Presidio of San Francisco, the chief of which was a redetermination of a tract known as the Rancho Ojo dé Agua dé Figueroa.

The rifle ranges at Angel Island have also been redetermined and suitable firing points established.

During the annual march of instruction of Light Battery K, First Artillery, the itinerary officer secured a series of notes which added somewhat materially to a knowledge of the roads between San Francisco and Monterey, chiefly in the mountainous coast regions. These notes were submitted to this office for reduction, and the results were recorded on the department map.

The office-work has been limited mainly to the new map of the Departments of California and the Columbia, which is now completed with the exception of some minor additions necessitated by the progress of several railroads. Other work has consisted of the mounting of a large number of maps for the division commander, the drawing of graduated arcs for heavy-gun firing and incorporation of information derived from various sketch maps into the general map of the departments above mentioned.

The only recommendation which appears to be necessary is for funds to aid in securing a more exact knowledge of certain regions in southeastern California. For this purpose an appropriation of $1,000 would be desirable.

Very respectfully, your obedient servant,

THOS. L. CASEY,
First Lieutenant of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

APPENDIX E E E.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF DAKOTA.

ANNUAL REPORT OF LIEUTENANT JOHN BIDDLE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

HEADQUARTERS DEPARTMENT OF DAKOTA,
OFFICE CHIEF ENGINEER OFFICER,
Saint Paul, Minn., July 7, 1887.

GENERAL: I have the honor to submit the following report of work performed in this office during the fiscal year ending June 30, 1887.

The office was moved from Fort Snelling, Minn., to Saint Paul, Minn., November 1, 1886.

Topographical Assistant E. H. Rakowiez has been on duty throughout the year. As the office force is limited to this one man the amount of work was necessarily restricted, although he is a quick and efficient draughtsman.

During August and September, 1886, the south line of the Fort Buford, Dak., military reservation was resurveyed by me and report submitted.

From the middle of September until November 1, 1886, I was on duty to assist commissioners detailed by the Interior Department to allot lands in severalty to the Crow Indians on their reservation in Montana. A report was submitted to the Assistant Adjutant-General.

On May 20 I left Saint Paul to make survey of Fort Buford, Dak., military reservation, returning June 25. A report has been prepared and submitted.

A new target range was laid off at Fort Snelling, Minn., during July and August, 1886.

Reports of hunting trips have been submitted by First Lieutenant Macaulay, Medical Department, and Second Lieutenant Robertson, First Cavalry. The latter one especially embraced considerable new and useful information.

Itineraries of the march of troops of the Seventh Cavalry from Fort Yates, Dak., and Fort Keogh, Mont., were submitted by Captains McDougall and Edgerly, Seventh Cavalry.

In the office the work has been constant, making tracings, blue-process photographs, mounting and distributing maps, etc. The plats of all the posts of the Department have been revised and brought up to date.

The descriptions of the boundaries of the different military and Indian reservations of the Department, with such itineraries as were deemed useful, were prepared in this office and published as a general order, headquarters Department of Dakota. These were furnished to all officers desiring them.

Respectfully submitted.

JOHN BIDDLE,
First Lieutenant, Corps of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

APPENDIX F F F.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE COLUMBIA.

ANNUAL REPORT OF LIEUTENANT WILLIAM C. LANGFITT, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1887.

HEADQUARTERS DEPARTMENT OF THE COLUMBIA,
ENGINEER OFFICE,
Vancouver Barracks, Wash., July 1, 1887.

GENERAL: I have the honor to submit the following report of engineer operations in the Department of the Columbia for the fiscal year ending June 30, 1887:

In obedience to Special Orders, No. 243, Headquarters of the Army, Adjutant-General's Office, dated October 19, 1886, I reported at these headquarters to the commanding general Department of the Columbia, and was assigned to duty as engineer officer per General Order No. 31, Paragraph II, dated Headquarters Department Columbia, December 14, 1886, relieving First Lieut. Edward Burr, Corps of Engineers.

PERSONNEL.

General Service Clerk A. Downing has been assigned to this office throughout the year

General Service Clerk C. A. Homan was assigned here also until December 1, 1886, when he was ordered to duty in the medical director's office; so that there is but one assistant now in this office.

FIELD WORK.

The following field work has been done:

Resurvey of the western boundary of the Vancouver Military Reservation.

Survey of the site of Columbia City in connection with the St. James Mission claim.

Survey of a portion of the St. James Mission claim lying within the Vancouver Military Reservation.

Also locating sites for new company and other quarters; surveys for new roads and of the old Territorial road within the limits of this reservation.

OFFICE WORK.

The following office work has been done:

Maps and plans drawn by hand	16
Tracings for issue and office files drawn	70
Solar prints made and issued during the year	178
Negatives pertaining to official records and views at this post taken during the year	25
Reports of scouts within the Department referred to this office for note	7
Copies of the Department map issued during the year	60

MISCELLANEOUS.

During the month of May I sent my assistant to Olympia, Wash., where he copied 120 new townships from the records of the surveyor-general's office in that city.

A number of new townships were also copied from the records of the surveyor-general's office, Portland, Oregon, together with much other new data from the several railroad offices and the United States engineer offices there.

This new matter is now being compiled upon the progress sheets (four in number) of the Department map, on a scale of 8 miles to 1 inch.

Standard time has daily been furnished by signal to the whole post from this office since January 1, 1887. This time is obtained in this office by telegraphic signal from Portland, Oregon, through the kindness of Mr. F. H. Lamb, assistant superintendent Western Union Telegraph Company.

Map mounting and other matters of routine pertaining to the engineer office at a department headquarters have been regularly attended to.

There have been no funds whatever available for the use of this office during the year.

The Quartermaster's Department has kindly furnished the drawing materials absolutely necessary for carrying on the work of the office.

Very respectfully, your obedient servant,

WM. C. LANGFITT,
First Lieutenant, Corps of Engineers,
Engineer Officer.

The CHIEF OF ENGINEERS, U. S. A.

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